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THE UNIVERSITY OF ALBERTA

FOURIER ANALYSIS FORECASTS OF HOVMÖLLER
DIAGRAM HEIGHTS

by



Phillip G. de Souza

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
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EDMONTON, ALBERTA

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THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read,
and recommend to the Faculty of Graduate Studies and
Research, for acceptance, a thesis entitled "Fourier
Analysis Forecast of Hovmöller Diagram Heights", sub-
mitted by Phillip de Souza in partial fulfilment of
the requirements for the degree of Master of Science,
in Meteorology.

E. Reinelt.....
Supervisor

Kenneth W. Hay.....

M. J.

Date *25 May 1978*.....

This is dedicated to my daughter,

Adrienne.

I got this finished, inspite of her.

ABSTRACT

A computer program was developed to analyze Hovmöller Diagram data.

The program uses Fourier Analysis to extract wave information from the individual reports. Fourier Analysis is used again to get information as to how these waves change with time. A 30-day forecast of the data is then made for the period covered by the next 60 reports.

The program was used on two sets of data obtained from the Atmospheric Environment Service, Department of Forestry and the Environment.

The results indicate a possible relation between the means of the reports and the solar radiation. Some forecast skill was shown when comparisons were made to climatology and persistence forecasts. However, the error in the best forecasts was rather large for operational applications at a Weather Office.

PREFACE

In 1949, E. Hovmöller (1949) introduced the Trough-and-Ridge Diagram. Such diagrams show how the 500-mb heights change with longitude and time. Oscillations or waves in these heights produce ridges and troughs which can be tracked for several days, weeks, and in the case of long waves, even months. Forecasters at the Atmospheric Environment Service (AES) have used this diagram as an aid to forecasting the movement of troughs, ridges, and energy pulses. In current practice, the forecast method is partly subjective and only indicates the possible locations at which rapid deepening of surface cyclones may occur.

A second method using Fourier Analysis has also been developed at AES, a numerical forecast scheme which predicts the 500-mb heights and, in this way, indicates the location and magnitude of possible deepening. At the time of writing, little is known about the accuracy of this method (see Balshaw(1975)).

This report examines two Fourier Analysis models for forecasting the 500-mb heights displayed in a Hovmöller Diagram.

The first model assumes that the mean of the

- heights and the amplitude of the waves are constant. The second model assumes that the mean and wave amplitudes vary with time. Forecasts of up to thirty days were produced using the second model and statistics are calculated to show the "skill" of the forecast method.

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and Mr. E. Goldberg.

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CHAPTER 1

INTRODUCTION

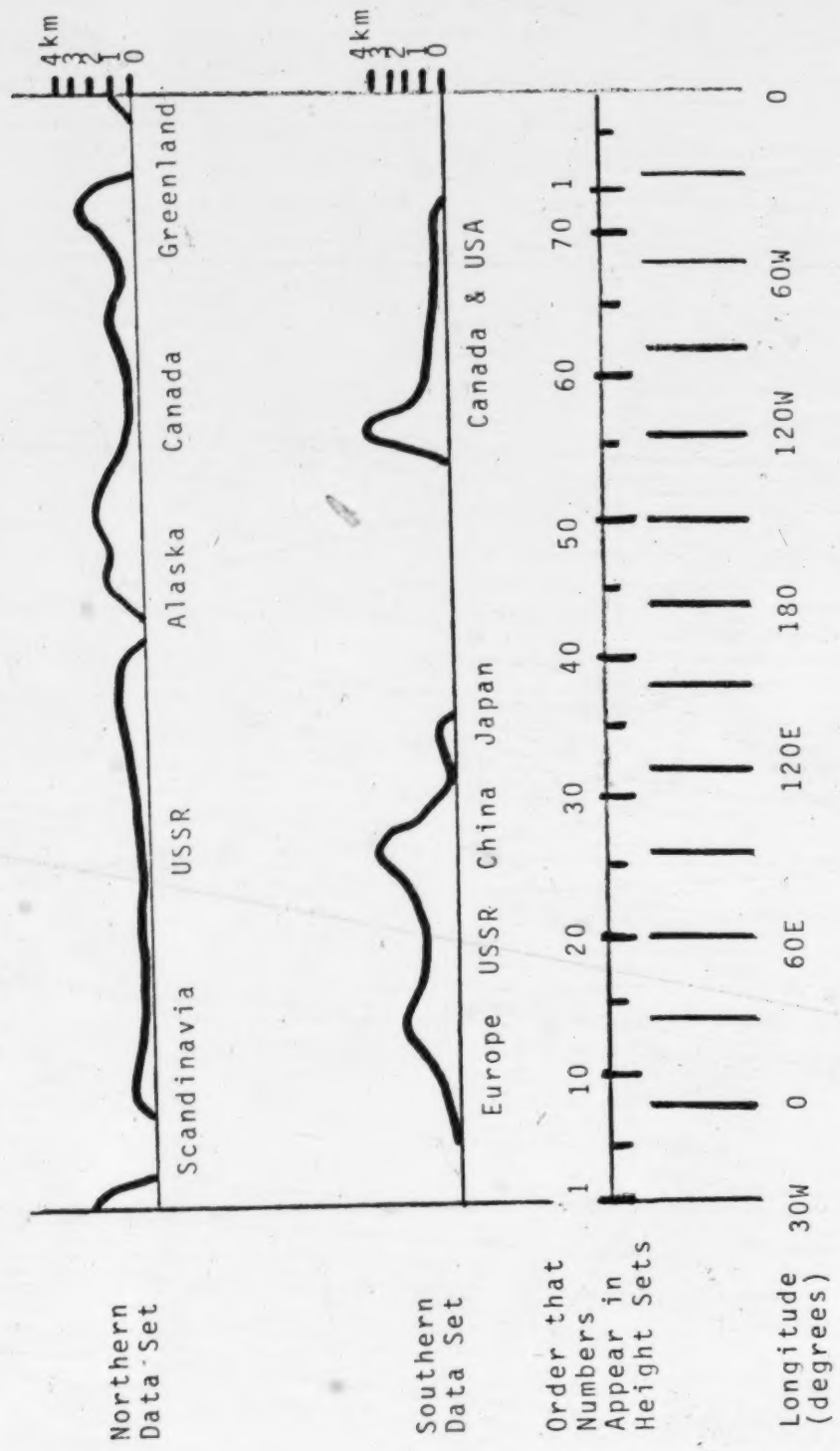
Analysis of Data

Every twelve hours, at 00 GMT and 12 GMT, two sets of seventy-two Hovmöller Diagram heights are produced at the Canadian Meteorological Centre (CMC). One set of heights refers to a latitude belt from 50°N to 75°N , the Northern Data set. The other set of heights refers to a latitude belt from 30°N to 65°N , the Southern Data set.

1.1 Height Set Production

Each of the seventy-two numbers of the height set is obtained by taking a six-point average, along a selected line of longitude, of the 500-mb heights within the latitude belt. The lines of longitude selected are five longitude degrees apart. The first number in the height set refers to 30°W longitude. Each succeeding number refers to the longitude line five longitude degrees to the east of the previous line. In this way, a report represents a set of heights averaged over a complete zonal band around the Earth. Figure 1.1 shows the posi-

Figure 1.1. Estimated Mean Surface Elevation Above Sea Level
In the Latitude Belt of Each Data Set



tion of the numbers and an estimate of the altitude of the surface at those longitudes for both Northern and Southern Data sets. The heights, reported by CMC, are in decameters (dam) with the hundreds digit deleted. This means that if one of the numbers is 56, then the actual average height for that line of longitude is 556 decameters. However, for the Northern Data set, this lack of a hundreds digit could produce possible ambiguities since a height coded as 99 could mean a height of 499 decameters or 599 decameters. These 499 dam or lower heights usually occur in the Northern Data set during winter. This possible problem was removed by subtracting 500 decameters from the actual heights. This changed some values to negative numbers. The height-sets were then punched on computer data cards and separated into the two groups, Northern and Southern Data sets.

There are two different ways to analyze the height data, either by graphical or by numerical techniques.

1.2 Graphical Techniques

Hovmöller(1949) was the first person to propose a method to analyze his Trough-Ridge diagram. His method as described in Balshaw et al.(1975) is still being used today. This technique consists of plotting the set of heights using longitude as abscissa and time as ordinate.

Then equi-height contours are drawn on the plot. Intervals of 10 decameters were used by Hovmöller, but other researchers have used different contour intervals. For example, Bjerknes(1957) used an interval of 4 decameters and AES forecasters use 6 decameters. Once contours have been drawn, areas of minimum heights (LOWS) and areas of maximum heights (HIGHS) are shaded in. At a specific time, the position of a height minimum or height maximum is called a trough or ridge, respectively. Lines connecting the various time positions of a trough or ridge are drawn to show the movement of these features.

Two types of waves can usually be diagnosed in these diagrams, long waves (wave no. 1 to 3) and major waves (wave no. 4 to 7). Long waves are usually slow moving or even stationary in the Hovmöller Diagrams. Major or secondary waves usually have trough or ridge lines sloping at varying angles to the abscissa. To forecast the height pattern, these trough and ridge lines are extrapolated past the most recent data. Constructive wave interference is expected at the location and time at which two trough lines or two ridge lines intersect. If two ridge lines intersect, then a HIGH is expected and, if two trough lines intersect, a LOW is expected. Reaction at the surface to these lows and highs can be expected about five longitude degrees to the east of these features.

1.3 Numerical Techniques

As mentioned previously, the height data at any given time are repetitive in space for every complete circuit around the Earth. Most numerical techniques take advantage of this fact and analyze the data using a Fourier Analysis. This produces values for the amplitude and phase of the dominant waves in the data. A dynamic equation such as Rossby's wave equation can then be used to forecast wave motion.* The Rossby wave equation is used by Balshaw et al.(1975).

1.4 Initial Model

The initial attempt at forecasting the heights for the Hovmöller Diagram also used a Fourier Analysis to extract space-wave information from the height sets. The formulas used were those of Jenkins and Watts (1968):

$$S(L) = A_0 + 2 \sum_{m=1}^k \{A(m)\cos(D(L,m)) + B(m)\sin D(L,m)\} \\ + A(k+1)\cos(D(L,k+1))$$

where $D(L,m) = \frac{2\pi}{N}(L-L_0)m$

* Page 255 Hess(1959) or page 144 Petterssen(1956). Another dynamic equation is the Cressman's equation (page 160 Petterssen(1956)).

L_0 = spatial origin of wave reference system = 37

L = spatial location of the height value in the CMC report set;
 $L = 1$ for the first number in the set, and
 $L = 72$ for the last number in the set.

$N = 72$ = the total number of values in the set

A_0 = the mean height of the set

$2B(m)$ = sine component of the amplitude of the space-wave having wave number m

m = wave number = number of space-waves required to completely circle the Earth

$k = \frac{N}{2} - 1$ = maximum number of waves having a non-zero sine component

$A(k+1)$ = amplitude of wave with wave number $k + 1$.

The amplitudes for these waves in space were calculated by:

$$A(m) = \frac{1}{N} \sum_{L=1}^N S(L) \cos(D(L,m))$$

$$B(m) = \frac{1}{N} \sum_{L=1}^N S(L) \sin(D(L,m)).$$

This form of the amplitude equations was converted to the amplitude - phase form by the equations:

$$S(L) = A_0 + \sum_{m=1}^k 2R(m) \cos(D(L,m) + Q(m)) \\ + R(k+1) \cos(D(L,m))$$

where $2R(m) = 2\sqrt{A(m)^2 + B(m)^2}$ = amplitude

$$Q(m) = \arctangent(-B(m)/A(m)) = \text{phase.}$$

This conversion requires that:

$$A(m) = R(m)\cos(Q(m))$$

$$B(m) = -R(m)\sin(Q(m)).$$

The Rossby wave equation was not used to forecast movement of the waves. Instead, a simple rate of phase-change equation was developed.

$$V(m) = \frac{\Delta Q(m)}{\Delta t} = \frac{1}{\Delta t} \arctan \left(\frac{B(0)A(t) - A(0)B(t)}{B(0)B(t) + A(0)A(t)} \right)$$

The derivation of this equation (see Appendix A) requires three assumptions. These assumptions are:

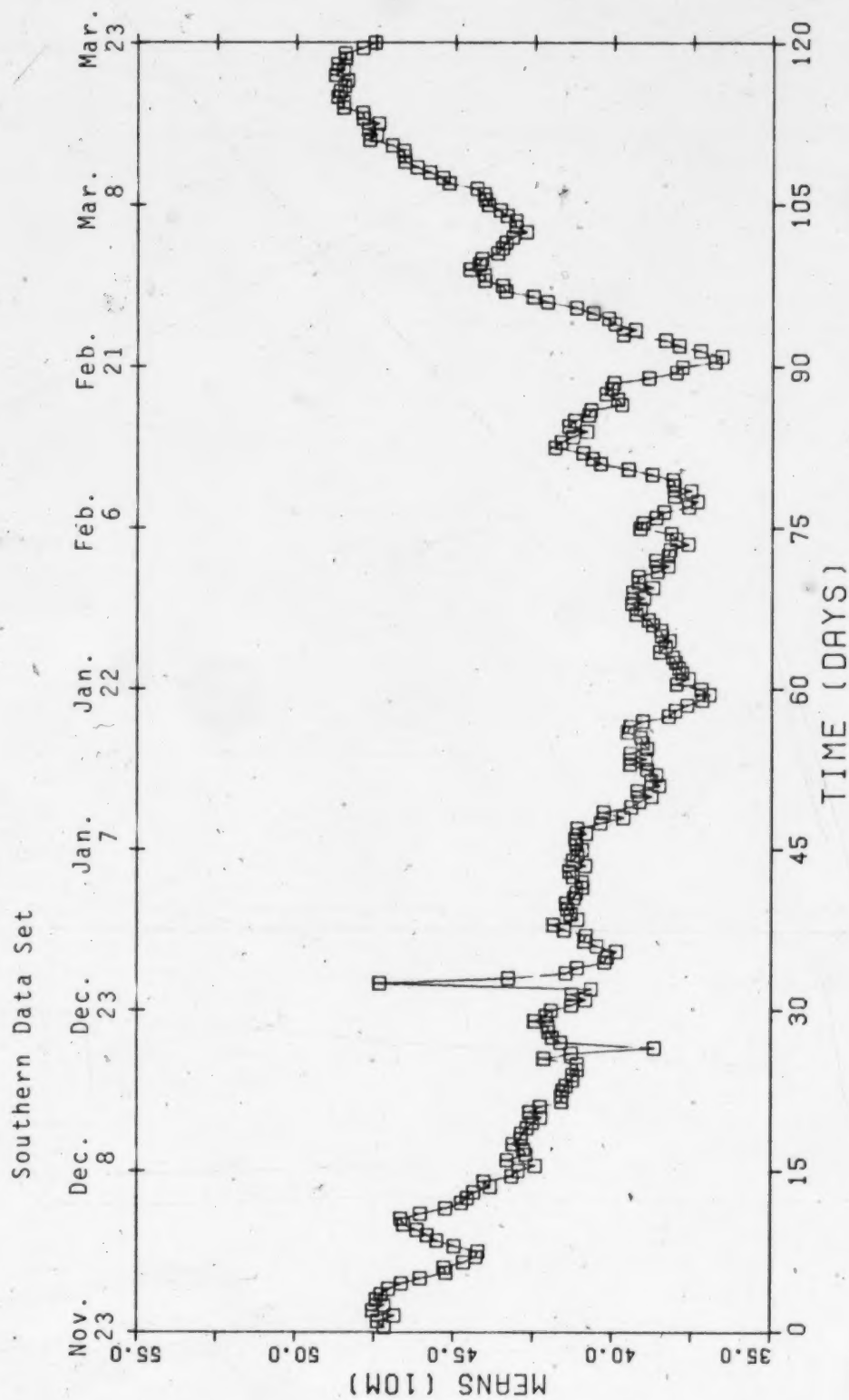
- 1) The mean of the data set at time zero is assumed equal to the mean of any other time,
 - 2) the amplitude of the space-waves, $2R(m)$, at time zero is assumed constant for all other times,
- and 3) the phase speed $V(m)$ is constant with time.

The rest of this chapter is a critical examination of these assumptions.

1.5 Assumption I: Height-Set Means

Figure 1.2 is a graph of the mean of height-set for Southern Data Set versus time. It can be seen in

Figure 1.2. Calculated Mean of the Height-Set for Time Shown
(Date or number of days from Nov. 22, 1976)



this figure, that the mean, A_0 , of the height-set is not constant with time. The error produced by a forecast made using Assumption I was as much as five decameters after fifteen days. This model would be required to forecast for as long as fifteen days to one month, with an accuracy of $\pm 5-10$ dam. Therefore, an error of five decameters for just the mean of the height-set was considered too large.

Examination of Figure 1.2 reveals two types of time fluctuations in the means. The first type was a long-term trend and the other fluctuation type was small amplitude "time-waves".

The trend was assumed to have a yearly period, and to be a function of time of the form

$$A_0(t) = D + H \cos\left(\frac{2\pi t}{730}\right) + C \sin\left(\frac{2\pi t}{730}\right)$$

where t has units of half-days. The coefficients D , H , and C were assumed to be constant with time. These coefficients were then determined using a least-square error fit of the means of the height-sets. The derivation of the least-square error formula is shown in Appendix B.

As expected, the calculated trend does fit the diagnostic means well. However, forecasts of the trend beyond the limits of the diagnostic means had a tendency to drift away from the actual means as the forecast time

increased. The error produced was in the range of five decameters for a ten-day forecast. This error was reduced as the number of diagnostic means increased.

Figure 1.3 shows the differences $Y(t)$ between the actual means used as diagnostic data $S(t)$ and the calculated trend $A0(t)$, so that

$$Y(t) = S(t) - A0(t)$$

If these differences were small, then they could have been neglected. However, some of these time deviations were as large as four decameters, and errors of this magnitude in the mean could not be ignored.

All in all, Assumption I was shown to be poor for the desired forecast period.

1.6 Assumption II: Wave Amplitudes

The second assumption is that the amplitude of each space-wave is constant with time. Figure 1.4 shows how the amplitude, $2R(m)$, of wave number $m = 1$, changes with time in the Southern Data Set. Other graphs of amplitude versus time can be found in Appendix C and D.

As expected from work with Hovmöller Diagrams, the largest amplitudes (10 to 15 dam) occur for space-waves that have wave numbers one to four. However, the

Figure 1.3. Differences Between Means of Reports and Calculated Trend
for the Time Shown. (Date or number of Days from Nov. 23. 1976)
Southern Data Set

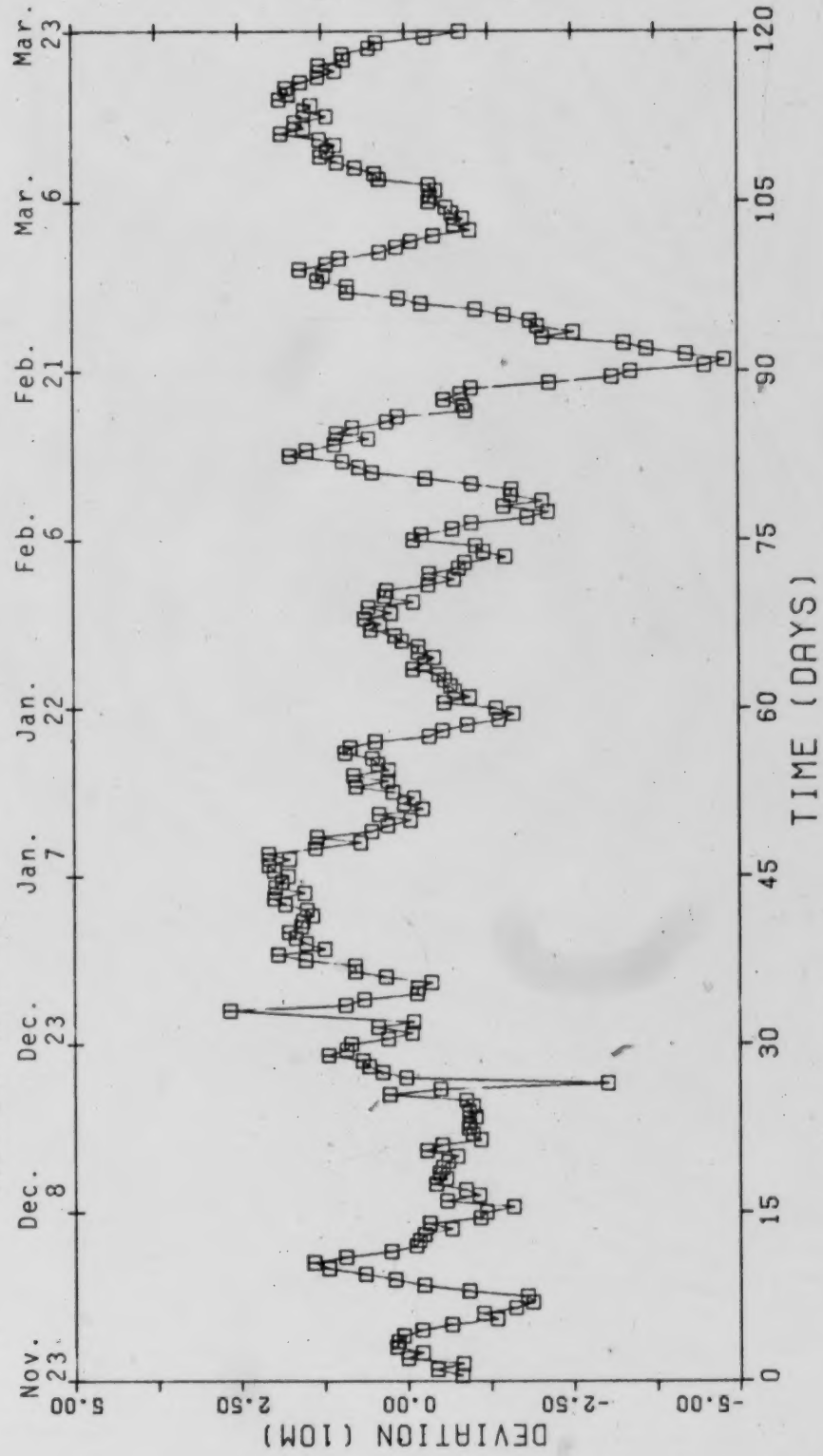
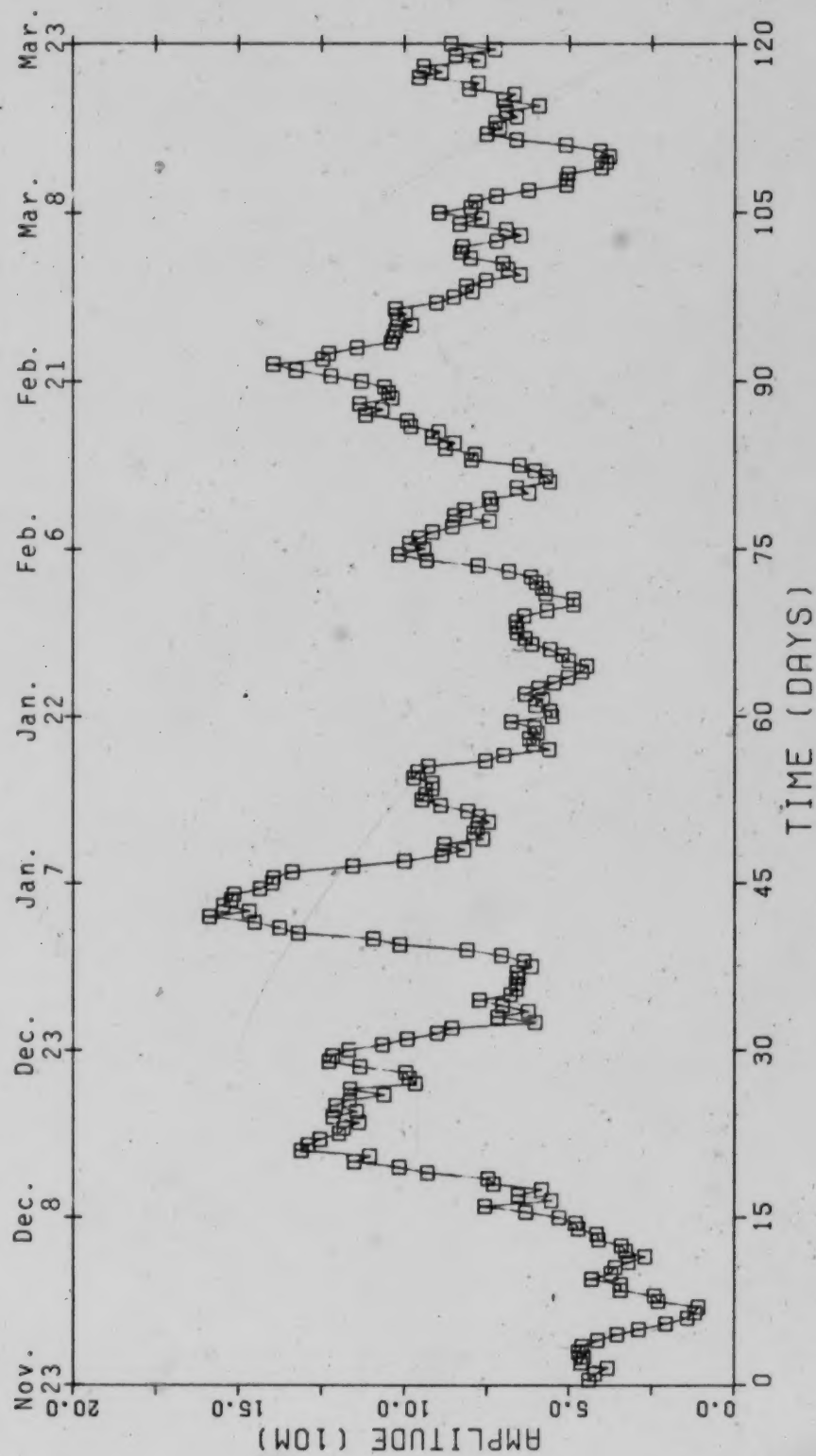


Figure 1.4. Amplitude of Space-Wave with Wave Number 1, for Time Shown

Southern Data Set



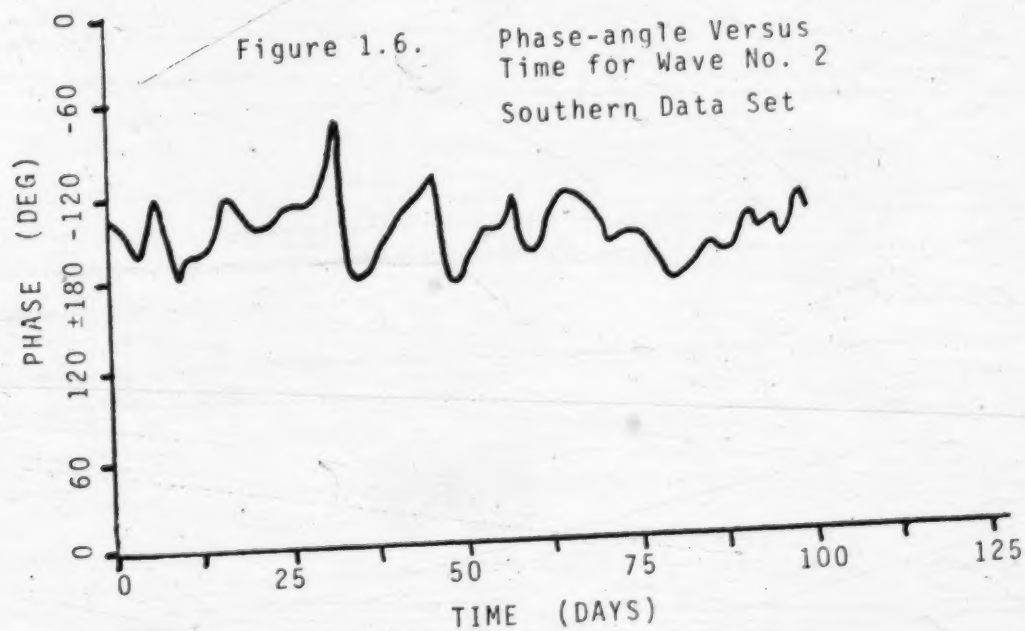
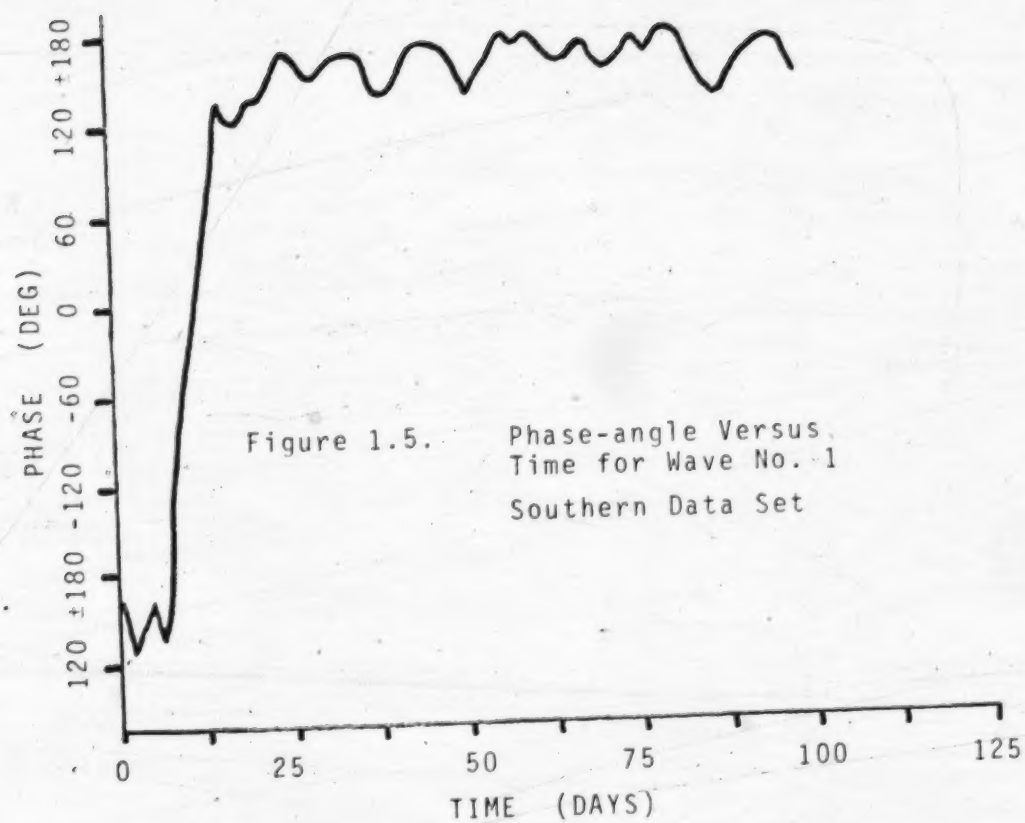
time fluctuations of amplitude for these space-waves were larger and more frequent than expected. For example, the amplitude of wave number 1 changed from 5 dam to 15 dam over a period of four days.

For space-waves with wave numbers five to twenty-five, the amplitudes decrease as wave numbers increase. After wave number 11, the maximum amplitude observed was less than 2 dam. For this reason, space-waves of wave numbers greater than eleven were ignored.

The time fluctuations observed in these space-wave amplitudes could have been produced by the Fourier Analysis calculation and might not have indicated a true time fluctuation in the waves in the atmosphere. These fluctuations were fairly smooth and continuous over two to four days of data, which indicates that a true dynamic process produced them. However, these time fluctuations were not consistent with Assumption II.

1.7 Assumption III: Wave Phase

The last assumption, that the change of phase-angle is constant with time, was also checked. The calculated phase-angle for each space-wave was plotted against time (see Appendix E). Figure 1.5 and 1.6 show corrected phase versus time plots for wave numbers 1 and 2. It can be seen in Figure 1.5 that



for most of the diagnostic period, wave number 1 is quasi-stationary, with a phase-angle of $+150^{\circ}$ (origin at 150°E longitude). For eight days, however, a rapid retrogression was detected with a speed of 150 km/hr or about 81 kts. (See Appendix F for method of calculating wave speed). This unexpected time fluctuation of phase-angle would be handled poorly by the initial model. Other graphs for the phase-angle versus time also show rapid fluctuations of phase-angle with time, which would indicate wave speeds of 15 to 20 kts., or about 25 to 35 km/hr.

The question again presents itself. Does the calculated fluctuation represent a true wave motion in the atmosphere? The phase-angle calculation

$$Q(m) = \arctan(-B(m)/A(m))$$

is sensitive when the ratio $-B(m)/A(m)$ is close to zero but insensitive when the magnitude of the ratio $-B(m)/A(m)$ is greater than four. This problem would not explain the slow 360° shift shown in Figure 1.5 but it might explain time fluctuations in the other space-waves.

Other problems associated with the amplitude-phase representation of the space-waves were:

- 1) The computer arctangent calculation only allows for phase-angles between ± 180 degrees.

When the phase-angle has a magnitude near 180 degrees, then a slight time fluctuation might cause a phase-angle sign change. This problem can be solved with proper computer programming but this was not attempted in this study.

and 2) Long-time averages over a 10 to 20 day period are required to produce smooth phase changes. This also was not attempted in this study.

These graphs show that not only is the phase hard to work with but also the assumption of constant phase velocity is not correct.

These studies of the three assumptions required to use the initial model showed the assumptions to be poor when actual data are used. Also, the various problems associated with the phase-angle calculation and interpretation suggest that adjustments to the model are needed for useful forecasts.

1.8 Final Numerical Model

The initial model had to be changed to a new form that would reproduce the Hovmöller Diagram heights with greater accuracy. The quantities A_0 , $A(m)$ and $B(m)$, that were assumed constant with time in the old model, were assumed to be periodic functions of time in the new model. The form of this time dependence was, for $A(m)$ and $B(m)$

$$A(m) \rightarrow A(t,m) = RA(m) + 2 \sum_{I=1}^{NWAVE} \{FA(I,m) \cos(E(t,I) + QA(I,m))\}$$

$$B(m) \rightarrow B(t,m) = RB(m) + 2 \sum_{I=1}^{NWAVE} \{FB(I,m) \cos(E(t,I) + QB(I,m))\}$$

where $NWAVE$ = maximum number of waves used to forecast amplitudes

m = wave number, $1 \leq m \leq 11$

$RA(m)$ = mean of cosine amplitude $\div 2$ for space-wave with wave number m

$RB(m)$ = mean of sine amplitude $\div 2$ for space-wave with wave number m

$2FA(I,m)$ = amplitude component of time-wave having wave number I . (cosine)

$2FB(I,m)$ = amplitude component of time-wave having wave number I . (sine)

$QA(I,m)$ = phase angle of forecast time-wave having wave number I . (cosine)

$QB(I,m)$ = phase angle of forecast time-wave having wave number I . (sine)

$$E(t,I) = \frac{2\pi \cdot I \cdot}{NUMB} (t - (\frac{NUMB}{2} + 1))$$

And, for the means of the height sets

$$AO \rightarrow AO(t) = RO + G \cos(\frac{2\pi t}{730}) + H \sin(\frac{2\pi t}{730})$$

$$+ 2 \sum_{I=1}^{NWAVE} \{K(I,m) \cos(E(t,I) + QO(I,m))\}$$

where RO = time mean of all height-set means

G, H = amplitudes of trend component

$2K(I, m)$ = amplitude of forecast time-wave
of differences $Y(t)$ mentioned in
section 1.5

$Q0(I, m)$ = phase of forecast time-wave of
differences $Y(t)$.

Note that the space-wave amplitudes do not have a trend
removal or a trend forecast.

CHAPTER 2

PROGRAM TO FORECAST HEIGHTS

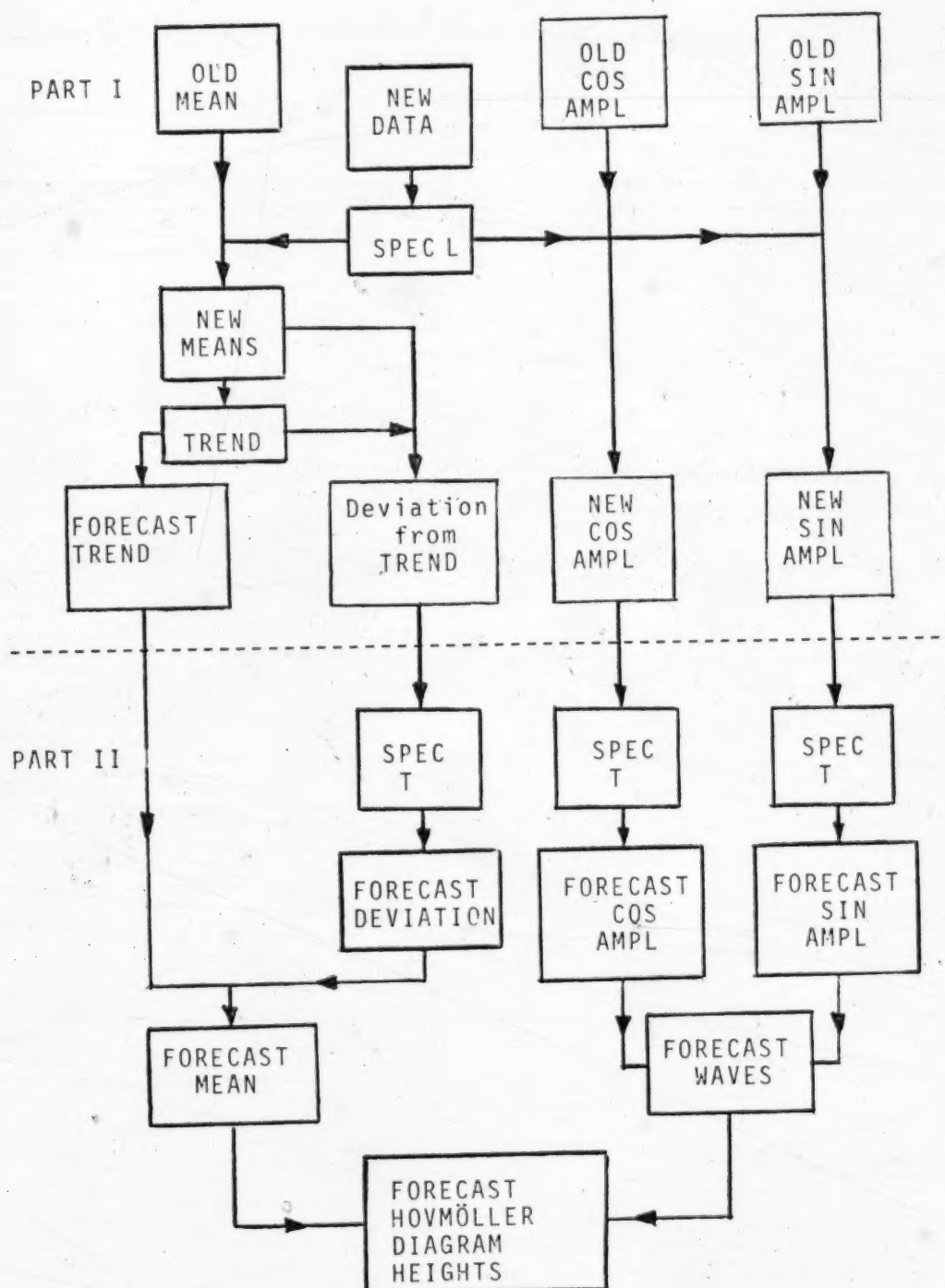
Figure 2.1 shows a block diagram of the two computer programs used to forecast Hovmöller Diagram Heights.

2.1 Program I: Data Collection

The first program collects data and updates diagnostic fields. As a new set of heights for time " t^* " is read into the computer, a space Fourier Analysis is performed on it. The mean height, $A_0(t^*)$, of each report becomes the last element in a vector, $Y(t)$, that contains previous means of diagnostic data for time $t=1$ to $t = t^*-1$. The 22 components of the space amplitude;2 i.e., $A(t,m)$ and $B(t,m)$, become the eleven elements in the last row of two storage matrices, $AAMPL(t,m)$ and $BAMPL(t,m)$, respectively. The first element in the rows of these matrices represents the component for wave number $m=1$, and the last element in the rows represents the component for wave number $m=11$.

Next, a least-square time analysis is performed on the means stored in vector $Y(t^*)$. This produces the

Figure 2.1. Block Diagram of the Two Parts of the Program



trend equation in the form previously given in section 1.8. The trend is calculated for the diagnostic data $Y(t^*)$ and is extended outside the diagnostic period for a thirty-day forecast period. The difference, between the real means in vector $Y(t^*)$ and the estimated trend $X(t^*)$ is computed and stored in vector $Z(t^*)$.

If a 12-hr report was missing for time t' , then three blank cards were read into the computer in its place. The program will then set the space amplitude components $A(t',m)$ and $B(t',m)$ equal to 99.99 for the eleven wave numbers, and the mean $Y(t')$ is set equal to zero. For the calculation of the deviation from the trend, $Z(t')$, the missing data are replaced by a local time average. This time average is taken over the six (or fewer) non-zero values of $Y(t)$, three on each "side" of $Y(t') = 0.00$. The complete listing and output of the first part of the height forecast program is shown in Appendix G.

2.2 Program II: Height Forecast

The second part of the program ** takes a time Fourier Analysis of the amplitudes in each column of the two matrices AAMPL and BAMPL, and it takes a time Fourier Analysis of the deviations in $Z(t^*)$. On each occasion that a time Fourier Analysis is carried out, the

** See Appendix H for a listing of Program II

resultant time-waves are sorted according to the magnitude of the time-wave amplitudes. Large-amplitude time-waves are listed first and small-amplitude time-waves are listed last.

At this point, the program can perform in various optional ways. To determine which of these options is used, five parameters must be specified (see Appendix I for a complete description of these parameters). The three most important of these parameters are NWAVE, PRINT and JWAVE. The first NWAVE of the sorted resultant waves are used to forecast the amplitudes in the columns of AAMPL and BAMPL, and to forecast the deviations $Z(t)$.

The second parameter, PRINT, is the most important. It allows forecasts to be made using persistence, climatology, unsmoothed time-waves, and smoothed time-waves. A persistence forecast ($PRINT = 4.0$) just repeats the most recent diagnostic report over the full forecast period*. A climatology forecast ($PRINT = \pm 5.5$) is equivalent to $NWAVE = 0$. This means that only the average of each column is used to make a time "forecast" of the amplitude in each column of AAMPL and BAMPL. It also means that the average of $Z(t)$ is used to "forecast" the deviations from the trend. For unsmoothed time-waves to be used, PRINT must have a value greater than 6.0. If

* For a persistence forecast, only the Verification Program needs to be run (see Appendix J).

PRINT is less than 3.5, time-smoothed waves are used to forecast the columns of AAMPL and BAMPL, and the deviations in $Z(t)$. This smoothing is performed on the time-waves before they are sorted according to magnitude.

The third important parameter, JWAVE, determines the number of space-waves (number of columns of AAMPL and BAMPL) to be used to forecast the heights. This parameter also can have a value from 1 to 11.

Once the number of space-waves, JWAVE, has been specified, the strongest NWAWE time-waves forecast the first JWAVE columns of AAMPL and BAMPL and the deviations from the trend $Z(t)$. The heights for a forecast time $(t+1)$ are then reconstituted from the forecast trend, the deviation from the trend $Z(t+1)$ and the forecast space-wave amplitudes in AAMPL $(t+1,m)$ and BAMPL $(t+1,m)$.

CHAPTER 3

SMOOTHING

The time variation of the frequency of the time-waves is one of the major problems with this forecast model. Therefore, instead of the wave being represented by a single frequency, as in the model, it should be represented over a frequency band, with the band width depending on the wave. This causes an error in the forecast of the space-wave amplitudes in the columns of the matrices AAMPL and BAMPL. The forecast program assumes that the time-waves, diagnosed in the columns of AAMPL and BAMPL, have a fixed wavelength during the whole forecast period.

To try and minimize the problem of wavelength variations during the forecast period, a time smoothing was performed in Program II. Three different smoothing options were tested.

3.1 Smoother Number 2

Lachapelle(1977) suggested one method of smoothing the waves. In this method the mean-square contribution for wave I, $AA(I)$, is calculated by the formula:

$$\{ \text{amplitude}/2 + \text{amplitude}/2 \} \cdot 2.$$

The average of $AA(I)$ over three waves is taken to be the smoothed mean-square. The frequency "f" is weighted using the mean-square as weights. Also the phase "Q" is smoothed by taking the average of the sine "BR" and cosine "AR" components. The arctangent of the ratio BR/AR is then taken to represent the smooth phase.

This method was used as one smoothing option. The only change was due to a different definition for the phase. Lachapelle(1977) used the form $R\cos(X-Q)$ in his time spectral analysis. In this program the form $R\cos(X+Q)$ was used. This required the arctangent of the ratio $-BR/AR$ to be used for the smoothed phase.

To switch between amplitude-phase and sine-cosine forms, use the formula:

$$\begin{aligned} B(I) &= -R(I)\sin(Q(I)) & AA(I) &= R(I)*R(I)*2 \\ A(I) &= R(I)\cos(Q(I)). \end{aligned}$$

$$\begin{aligned} \text{For wave number } I, \text{ smooth mean-square} &= \{AA(I-1) \\ &+ AA(I) + AA(I+1)\}/3 \end{aligned}$$

$$AR = \{A(I-1) + A(I) + A(I+1)\}/3$$

$$BR = \{B(I-1) + B(I) + B(I+1)\}/3$$

$$\text{smooth phase} = \text{arctangent} (-BR/AR)$$

$$\text{smooth frequency} = \frac{f(I-1) \cdot AA(I-1) + f(I) \cdot AA(I) + f(I+1) \cdot AA(I+1)}{AA(I-1) + AA(I) + AA(I+1)}$$

This formulation appeared to produce smooth phase-angles, but forecasts made using these smoothed angles showed phase shift problems when compared to the diagnostic data. Two other smoothing techniques are available in the program. Smoother No. 1 and Smoother No. 3 are both slight variations of Smoother No. 2, that try to couple the calculation of smooth phase and smooth amplitude.

3.2 Smoother Number 1

In this option the frequency and phase were both smoothed as in Smoother No. 2. However, the mean-square was calculated from a formula similar to that used to add three vectors in two dimensions. The resultant vector magnitude represents the smooth amplitude and its direction represents the phase. For wave number I

$$AR = \{A(I-1) + A(I) + A(I+1)\} / 3$$

$$BR = \{B(I-1) + B(I) + B(I+1)\} / 3$$

as before, but the smooth mean-square = $2(AR^2 + BR^2)$.

This linked the calculation of the smooth mean-square and the smooth phase by using AR and BR in both.

3.3 Smoother Number 3

This option uses the mean square in both the

smooth phase calculation and the smooth mean-square calculation. For the smooth phase calculation, a problem arises since the mean-square is always positive and contains no phase information. To counteract this problem the program uses the form $2(\text{magnitude } R) \cdot R$, instead of the mean-square, to preserve the sign.

For wave number 1:

$$AR = \left\{ \frac{A(I-1) \cdot |A(I-1)| + A(I) \cdot |A(I)| + A(I+1) \cdot |A(I+1)|}{3} \right\}$$

$$BR = \left\{ \frac{B(I-1) \cdot |B(I-1)| + B(I) \cdot |B(I)| + B(I+1) \cdot |B(I+1)|}{3} \right\}$$

$$\text{smooth mean-square} = (|AR| + |BR|)^2$$

$$\text{smooth phase} = \arctan (-BR/AR)$$

The following example demonstrates the results of these smoothing options:

Initial Waves

I	Frequency f(I) cycles per hour	A(I) cos dam	B(I) sin dam	R(I) AMPL dam	Q(I) PHASE DEG	AA(I) MEAN-SQ DAM SQ
1	0.00093	-0.2534	-1.1743	1.20263	102.46	2.89266
2	0.00185	-0.9484	0.2382	0.97782	-165.90	1.91228
3	0.00278	0.1283	-0.2334	0.26632	61.20	0.14185

Result of the smoothing options, used for wave number 2
are:

<u>f(I)</u>	<u>A(I)</u>	<u>B(I)</u>	<u>R(I)</u>	<u>Q(I)</u>	<u>AA(I)</u>
unsmoothed					
0.00185	-0.9484	0.2382	0.978	-165.9	1.91228
smoother #1					
0.00134	-0.35783	-0.38983	0.529	132.5	0.56002
smoother #2					
0.00134	-0.61334	-0.66945	0.908	132.5	1.64893
smoother #3					
0.00134	-0.43896	-0.63870	0.775	124.5	1.54921

3.4 Variance Equalization

The total variance is calculated from the sum of the mean-square for each frequency. This variance changes when the mean-squares are smoothed. The program attempts to make the variance after smoothing "SRMAX" equal to the variance before smoothing "SUM". This equalization is performed in the smoothing subroutine by multiplying the power fraction $AA(I)/SRMAX$ by the variance "SUM". This adjustment technique does not bring the smooth amplitude to the same magnitude as that of the un-smoothed amplitude.

3.5 General Comments on the Smoothing Options

The greatest problem that occurred with the

smoothing method was the calculation of a smooth phase. As mentioned previously, Smoother No. 2 and No. 1 both appear to produce phase shifts of ± 20 degrees for the strongest smooth waves relative to the strongest unsmoothed waves. For a very strong wave, the amplitude would be reduced slightly by smoothing and the phase and frequency should not change. Smoother No. 3 produces little phase-change (± 3 degrees) for these strong waves.

In each of the smoothing options the first frequency is smoothed by taking the average between the first and second frequency. The last frequency is never smoothed and is assumed so small that it is not even printed out (only the first 40 frequencies are printed out).

CHAPTER 4

VERIFICATION

4.1 Statistics Used

Sixty 12-hour forecasts were made for the 30-day period after the last day of diagnostic data. Several statistics were generated for each of these forecasts.*

These statistics were:

The mean of the forecast $S0 = \frac{1}{72} \sum_{I=1}^{72} S(I)$

The mean of the real data $Y0 = \frac{1}{72} \sum_{I=1}^{72} Y(I)$

The mean difference $= S0 - Y0 = \frac{1}{72} \sum_{I=1}^{72} \{S(I) - Y(I)\}$

The biased standard deviation of the forecast

$$SS = \sqrt{\frac{1}{N} \sum_{I=1}^{72} (S(I) - S0)^2}$$

The biased standard deviation of the real data

$$SY = \sqrt{\frac{1}{N} \sum_{I=1}^{72} (Y(I) - Y0)^2}$$

$$\text{The mean absolute difference} = \frac{1}{N} \sum_{I=1}^{72} |Y(I) - S(I)|$$

* See Appendix J for verification program listing.

The mean-square error of estimate MSE =

$$\frac{1}{N} \sum_{I=1}^{72} \{Y(I) - S(I)\}^2$$

The correlation coefficient

$$R = \frac{\sum_{I=1}^{72} \{S(I) - S_0\} \{Y(I) - Y_0\}}{\sqrt{72 \cdot SS \cdot SY}}$$

The correlation coefficient without the mean removed

$$COF = \frac{\sum_{I=1}^{72} Y(I) \cdot S(I)}{\sqrt{\sum_{I=1}^{72} Y(I) \cdot Y(I)} \cdot \sqrt{\sum_{I=1}^{72} S(I) \cdot S(I)}}$$

Here, the real data referred to were the actual CMC reported heights. These data were not used in the diagnostic data sets. Therefore, the statistics generated do not depend on the diagnostic data but show how the forecasts would verify in an operational forecast office.

The values of the statistics "R" and "MSEE", the correlation coefficient and the mean-square error of estimate, respectively, seemed to correspond well with subjectively determined good and bad forecasts. Since the forecast model was designed to produce "good" long range forecasts, the average R and the average MSEE of the first 28 forecasts were used as indications of "goodness" of the total forecasts.

4.2 Test Sample

To see if the whole program could forecast heights accurately, a test data set was produced. This test sample set contained 11 space-waves and each of these space-waves contained three time-waves.* A yearly trend was also added to the mean of each test report. The test sample repeated itself after 30 reports, except for the yearly trend.

Near perfect forecasts were made when the program was used with diagnostic data sets of length 30 reports and the time-waves unsmoothed. The length of the diagnostic sets, NUMB, was increased to 44 and 52 reports and forecasts made. The results of these forecasts are discussed below.

4.3 Results Using a Test Sample

Figure 5.2 shows how the mean R and mean MSEE statistics were related for the forecasts for various sizes "NUMB" of the test diagnostic data sets. The relation of these means was a linear one with

$$R = 1.00 - \frac{MSEE}{92}.$$

Since these two statistics were related, only one need

* See Appendix K for a listing of this program.

be discussed. For NUMB = 30, the maximum MSEE was 4.2 (dam)² over a nine-day period. This excellent result indicates that the program works for data which exactly fit the model.

One of the problems of using a Fourier Analysis model is called wave truncation. This means that the wave being analyzed does not complete an integer number of cycles in the diagnostic data. This problem would cause small errors in the forecast if the truncated wave has a small amplitude. However, if the amplitude of the truncated wave is large and if the wave does not complete even one cycle then the error in the forecast can be large.

To see how the program handles truncated waves, the test sample was used with NUMB = 44 and 52. For NUMB = 44 the longest waves completed only one and one half cycles. Table 4.1 shows how the values of MSEE changed with the forecast time for unsmoothed time-waves and smoothed (Smoother No. 2) time-waves. The values in this table show that smoothing the time-waves does reduce the error caused by wave truncation.

Table 4.1 also shows the values of the mean-square of estimate for forecast having a diagnostic data set length of fifty-two (i.e. NUMB = 52). The long time-waves in this data set only complete 1.7 cycles. Since the forecasts for NUMB = 44 and NUMB = 52 refer to

TABLE 4.1

PROGRAM TEST USING SAMPLE DATA

Forecast Time ($\frac{1}{2}$ days)	NUMB = 44		NUMB=52	Forecast Time($\frac{1}{2}$ days)
	Unsmoothed MSEE	Smoothed MSEE	Smoothed MSEE	
1	42	48		
2	67	49		
3	106	30		
4	62	40		
5	32	27		
6	14	21		
7	38	30		
8	16	15		
9	53	26	26	1
10	21	10	29	2
11	73	25	13	3
12	67	15	14	4
13	92	12	23	5
14	59	8	15	6
15	82	17	30	7
16	94	34	8	8
17	126	46	26	9
18	86	21	18	10
19	62	51	26	11
AVERAGE	60	28	25	12
			33	13
			34	14
			32	15
			44	16
			64	17
			26	18
			40	19
			28	AVERAGE

Change of mean-square error of estimate with forecast time, for unsmoothed time-waves and smoothed (Smoother No. 2) time-waves. For these forecasts NWAWE = 11 and JWAVE = 8.

different times, the values in Table 4.1 are displaced so that they refer to the same times. For NUMB = 52, more data were available than for NUMB = 44. The MSEE values for these forecasts should be less than the values with NUMB = 44. This was not the case. Both sets of height forecasts used smoother option No. 2, both were variance adjusted, and both had mean MSEE = 28 for the first 19 forecasts made. This indicates that the smoothing process needs more data, say several more complete cycles, before a noticeable increase of forecast accuracy can be obtained. The change from 1.5 to 1.7 cycles is not enough.

4.4 Other Smoothing Methods

The smoothing options mentioned in Chapter 3 were not the only smoothing techniques tested with the test sample data. Several other methods that were tested are:

- 1) Smoother No. 2 with the variance not adjusted,
- 2) Smoother No. 2 with the variance not adjusted and the mean-square of the first smooth wave found by

$$\frac{AA(0) + AA(1) + AA(2)}{3}$$

where $AA(0) = 0.00$, always,

- 3) Smoother No. 2 with variance adjusted but first wave not smoothed,
- 4) Smoother No. 2 with all frequencies not weighted,

and 5). Smoother No. 2 with all frequencies not weighted and first time-wave not smoothed.

The results of these smoothing methods are shown in Appendix L. From these tests, it is clear that the following produced lower average MSEE values:

- 1) Variance equalization
- 2) Weighted frequencies
- and 3) Smoothing first time-wave, using mean-square

$$\text{formula} = \frac{AA(1) + AA(2)}{2}$$

CHAPTER 5

RESULTS USING SOUTHERN DATA SET

5.1 Testing the Trend

Part 1 of the program was used with various values of NUMB (i.e. diagnostic data sets of various lengths) to test the trend calculation. The trend equation tested was;

$$AO(t) = D + H \cos\left(\frac{2\pi t}{730}\right) + C \sin\left(\frac{2\pi t}{730}\right)$$

In Table 5.1, the values of the coefficients (D, H and C) are shown for each value of NUMB. It can be seen that the value of these coefficients approach limits as the value of NUMB increases. To see how stable these limits were for different samples of the Southern Data set, tests were made with NUMB kept constant at 256, but the starting and ending time of the diagnostic data adjusted. Table 5.2 shows the results for eight of these tests. The average value of the coefficients and the unbiased estimate of the standard deviation are shown below.

$$\begin{aligned} D &= 56.8 \pm 0.9 \text{ dam} \\ H &= -9.1 \pm 0.6 \text{ dam} \\ C &= -15.5 \pm 1.0 \text{ dam} \end{aligned}$$

Table 5.1. Coefficients of Trend Equation, Mean Deviation from Trend, and Unbiased Variance for Various Values of NUMB

NUMB	D dam	H dam	C dam	MEAN dam	VARIANCE (dam) ²
5	13.3	33.9	3.0	0.000	0.065
10	-148.9	196.3	-1.4	0.000	0.096
15	-318.8	366.4	-3.2	0.001	0.129
20	234.3	-186.3	-31.4	0.000	0.546
25	110.6	-63.0	-18.3	0.000	0.626
30	19.7	27.8	-10.6	0.000	0.661
35	6.1	41.2	-9.4	0.000	0.605
40	32.9	23.5	-11.6	0.000	0.539
45	30.2	17.3	-12.4	0.000	0.487
50	35.3	12.2	-13.2	0.000	0.439
60	73.3	-25.3	-20.5	0.000	0.647
65	89.8	-41.6	-24.2	0.000	1.150
70	83.3	-35.3	-22.6	0.000	1.178
75	77.5	-29.6	-21.1	0.000	1.148
80	78.7	-30.7	-21.4	0.000	1.080
85	76.7	-28.8	-20.8	0.000	1.022
90	74.9	-27.0	-20.3	0.000	0.973
95	72.4	-24.6	-19.5	0.000	0.942
100	65.2	-17.7	-17.0	0.000	1.048
105	59.0	-11.8	-14.8	0.000	1.134
110	56.4	-9.3	-13.8	0.000	1.116
120	50.4	-3.6	-11.3	0.000	1.186
125	49.4	-2.7	-10.9	-0.007	1.158
130	49.2	-2.5	-10.8	-0.012	1.118
135	50.1	-3.3	-11.2	-0.013	1.091
140	51.1	-4.2	-11.7	-0.015	1.070
145	51.0	-4.1	-11.7	-0.014	1.037
150	50.6	-3.8	-11.5	-0.013	1.014
155	50.2	-3.5	-11.3	-0.012	0.996
160	49.9	-3.2	-11.1	-0.011	0.973
165	51.7	-4.8	-12.1	-0.012	1.076
170	53.3	-6.2	-13.0	-0.012	1.097
180	52.9	-5.8	-12.7	-0.012	1.161
200	54.2	-6.9	-13.7	-0.010	1.579
210	55.1	-7.7	-14.4	-0.009	1.561
240	58.4	-10.3	-17.0	-0.006	1.748
298	56.4	-8.9	-15.1	0.002	1.493

Table 5.2 Values for Trend Coefficients
for Different Samples which
have the same value of NUMB

End Point		D dam	H dam	C dam
1	257	57.8	-9.9	-16.5
10	266	57.8	-9.8	-16.4
20	276	57.6	-9.5	-16.3
30	286	56.8	-9.1	-15.5
40	296	56.8	-8.9	-15.5
50	306	56.7	-8.7	-15.5
60	316	56.2	-8.4	-14.8
70	326	55.0	-8.5	-13.5
Average		56.8	-9.1	-15.5

The maximum deviation from the mean for any of these coefficients was 2 dam. However, a steady change in value of the coefficients was observed as the diagnostic data set was displaced in the direction of increasing time. Since the program only retains a maximum of 300 reports for diagnostic purposes, some method of storage of trend information was required to carry out a more stable coefficient calculation.

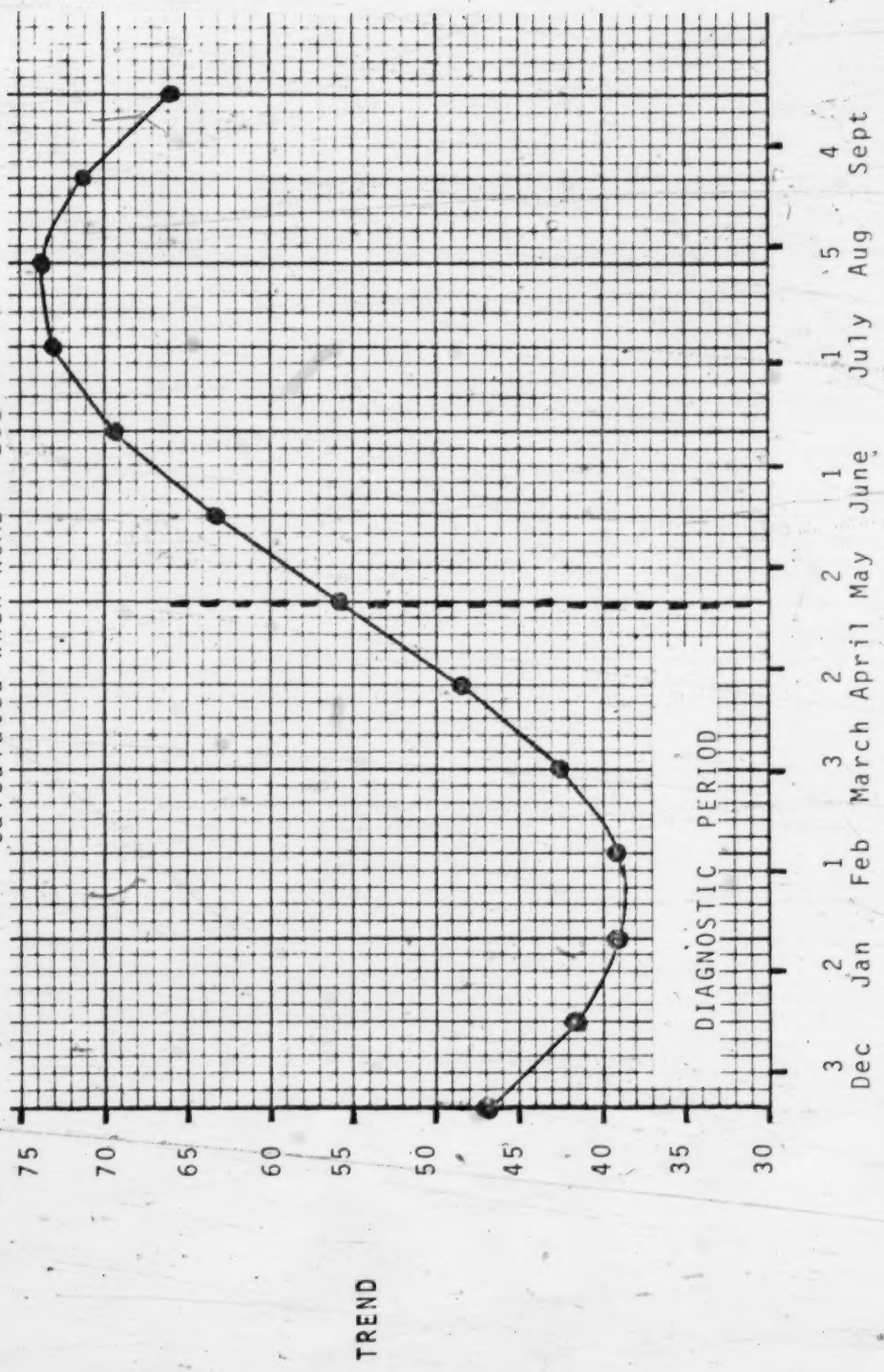
The method used in the program is to store the various parameters that are needed to calculate the coefficients D, H, and C. When new reports are read into the computer, the stored parameters are updated and then new coefficients are calculated.

Figure 5.1 shows the trend values calculated, when NUMB = 298. The maximum, indicated by the trend, occurred within two days of the actual maximum in the means and had a value within 1 dam of the actual maximum. The minimum value of the trend occurred during the diagnostic period and fit the means quite well. However, no statistics were calculated to indicate how well these trend values fit the means of all available reports.

Also, a comparison can be made of the trend curve, (Figure 5.1), and the curve for the net solar radiation arriving at the Earth's surface (see page 133 in Hess(1959)). The two curves appear to be highly correlated, with an estimated time lag of 25 days in

Figure 5.1. The Yearly Trend, of the Southern Data Set,

Calculated when NUMB = 298



the trend curve. This correlation justifies the previous assumptions of a yearly trend.

Two statistics were calculated to indicate the trend values' goodness of fit to the means of the reports.

These statistics were:

the mean deviation from the trend $MEAN = \frac{1}{N} \sum_{i=1}^{NUMB} Z(t)$

and the unbiased variance of the deviation around the trend

$$Variance = \frac{1}{NUMB-1} \sum_{i=1}^{NUMB} Z(t)^2$$

For this variance calculation it is assumed that the MEAN is equal to zero since the least-square fit minimizes this mean deviation squared. Also note that all data are used for trend calculation. Errors in the data set produced by estimating missing data report means, or any poor CMC analysis producing an abnormal mean are also used.*

5.2 Forecasts of Height Reports

Forecasts were made with the three smoothing options previously mentioned (NO. 1, NO. 2 and NO. 3) and the unsmoothed option. Sixty forecasts were made, one every 12 hours. For the first 28 forecasts the average

* See Figure 1.1 for time 26.5 and 32.5 - Dec 20, 00Z and Dec 26, 00Z, 1976, respectively.

MSEE and average R were calculated. Since the use of two statistics made it hard to compare the accuracy of forecasts, a new statistic was defined.

$$r^* = \sqrt{(100\text{dam}(1-R))^2 + \text{MSEE}^2}$$

where r^* has units of decameters-squared.

Figure 5.2 shows the average R plotted against average MSEE for various forecasts. The lines go through $R = 1$ and $\text{MSEE} = 0$. Also, they go through the mean value for the forecast made, having the same NUMB. The statistic r^* represents the "distance" of the forecast values of average R and average MSEE from $R = 1.00$ and $\text{MSEE} = 0.00$. Table 5.3 shows these values of r^* for the various forecasts. See Appendix M for actual forecast results.

5.3 Observations

As expected, the persistence forecasts give the best results over periods of 12 to 36 hours. However, persistence forecasts generally give poor results for periods beyond 36 hours. Also, from Figure 5.2, it can be seen that the persistence forecasts have slightly higher correlation with the actual heights than would be predicted from the line through the means of forecasts. The persistence values also indicated how rapid the height field changed during the forecast period (large r^* indicating rapid change).

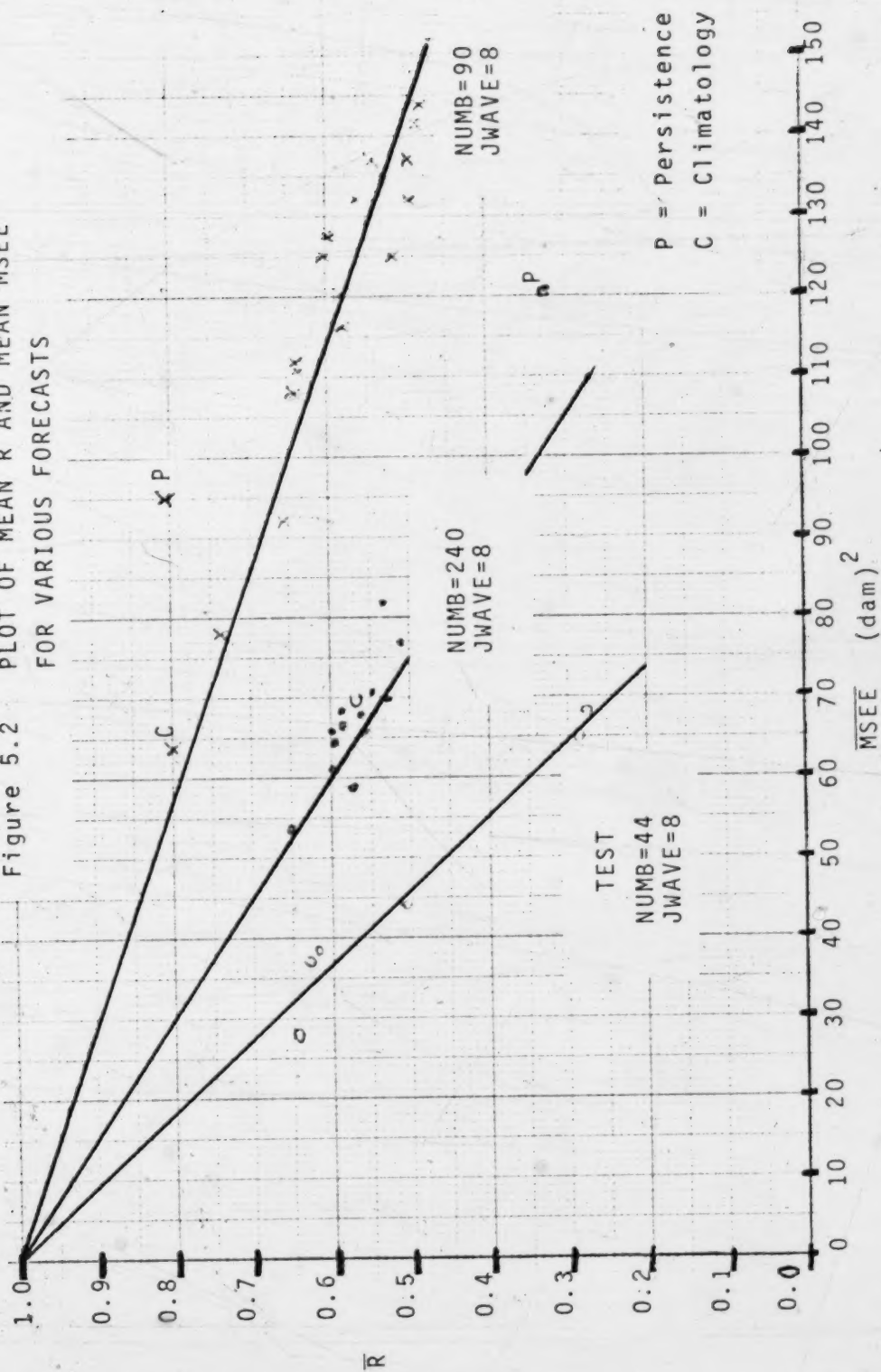
Table 5.3. The Values of r^* Determined From the First 28 Forecasts, for Various Forecast Options

Various Forecast Operations

NUMB	Smoother Used	JWAVE = 8							Persistence	Climatology
		NWAVE								
		1	2	3	4	5	6	11		
60	NONE							157		
	2							124		
90	NONE	98	125	134	141	146	151	153	97	67
	1						139			
	2	82	118	114	117		132	133		
	3			127			143			
240	NONE	72	73	84					138	81
	1	78			94					
	2	73	84		91					
	3	64	76	79	80	81				
		NWAVE = 2								
		JWAVE								
		5	8	11						
240	3	74.8	76.4	76.5						

Where: NUMB = Size of diagnostic data set
 NWAVE = Number of time-waves used
 and JWAVE = Number of space-waves used.

Figure 5.2 PLOT OF MEAN R AND MEAN MSEE
FOR VARIOUS FORECASTS



Values of R and MSEE for climatology forecasts indicate how rapidly the height field changes compared to the average over the diagnostic period. For a small diagnostic data set (NUMB = 90) the climatology results over the first twenty-eight forecasts had a lower r^* than the forecasts using the larger diagnostic data set (NUMB = 240). This is a similar characteristic to a persistence forecast since the "closer" diagnostic data set (NUMB = 90) produced the better forecasts. Since the climatology forecast for the group, NUMB = 240, was poor (i.e. r^* large), then the forecasts with time added to climatology usually produced better forecasts (i.e. r^* small).

Looking at the R and MSEE values for the forecasts using time-waves, it can be seen that unsmoothed time-waves gave good results for the initial forecasts but gave bad results for later forecasts, a consequence of not tapering** the diagnostic data set at the ends. On the other hand, the forecasts produced, using smoothed time-waves, had no preferred period for good or bad forecasts. This was due to the change of phase, amplitude and frequency produced by the smoothing options.

Usually the wave amplitude AAMPL (t,m) had one

** See Kanasewich(1975) page 98, for a description of tapering.

or two well-separated strong waves in the data (for $m = \text{constant}$). The smoothing techniques, however, would cluster the smoothed waves (usually 3) around the frequency of each actual strong wave. When the program selected the three strongest time-waves, it usually got three smoothed time-waves that clustered around the strongest unsmoothed time-wave, and would not use any information from the second or third-strongest unsmoothed time-wave. The resultant wave amplitude produced from the combination of the three waves was larger than the original strong wave. The example below demonstrates this clustering in the smoothed waves.

Example: These data are taken from the computer printout using actual height and wave-amplitude data. NUMB = 240 and the amplitude :2 being analyzed for time-waves were in AAMPL (t,3) (i.e. cosine component of space-wave number 3)

	Frequency Cycles per Hour	R (dam)	Q (degrees)	AA (dam) ²
Actual Waves	.00208	.067	-101	.00907
	.00243**	.530	76	.56185
	.00278	.207	130	.08642
Smoothed Waves (Smoother Number 3)	.00233	.3587	79	.25729
	.00247	.3519	90	.24767
	.00260	.3955	105	.31286

** Frequency of wave with large amplitude, around which the smooth waves cluster.

For this example, the maximum amplitude that these three waves can obtain, if constructive interference occurred, would be 1.6 dam for the actual wave and 2.1 for the smooth wave. This error in the amplitude in AAMPL, would produce a height error introduced not only by a phase-change, but also by an amplitude change in the space-wave. The program can't discriminate between the frequencies of the sorted strong wave. Therefore, it can't skip from one set of clustered frequencies to another to use as much information as is available.

Changes in the number of space-waves (JWAVE) used to produce the height forecasts appeared to produce only a slight change in accuracy of the forecasts (see bottom part of Table 5.3). For small JWAVE, an improvement was seen in the forecasts. Also, as the diagnostic data set size (NUMB) increased, a slight improvement was noted in the forecasts. This is indicated in Figure 5.2 by the grouping of the forecasts closer to a perfect forecast ($R-1$, $MSEE = 0$).

CHAPTER 6

RESULTS USING THE NORTHERN DATA SET

6.1 Trend Calculations

The trend coefficients D, H and C, were poorly defined for the Northern Data Set. Table 6.1 shows that the values of the coefficients continued to fluctuate even when the diagnostic data set was large. This lack of stability was due to the large and rapid fluctuations in the means of the height sets (See Figure 6.1). The diagnostic data set covered the period Dec 1, 00Z, 1976, to March 30, 12Z, 1977. In this latitude belt this is winter and, as expected, the heights are consistently low. It also meant that no noticeable spring warming had occurred as yet. The resultant trend was quite flat, but did indicate a minimum mean around day 80 (Feb 18). This is slightly later than the date of the minimum in the Southern Data set, and supports the assumption that the trend is produced by solar heating.

6.2 Observations

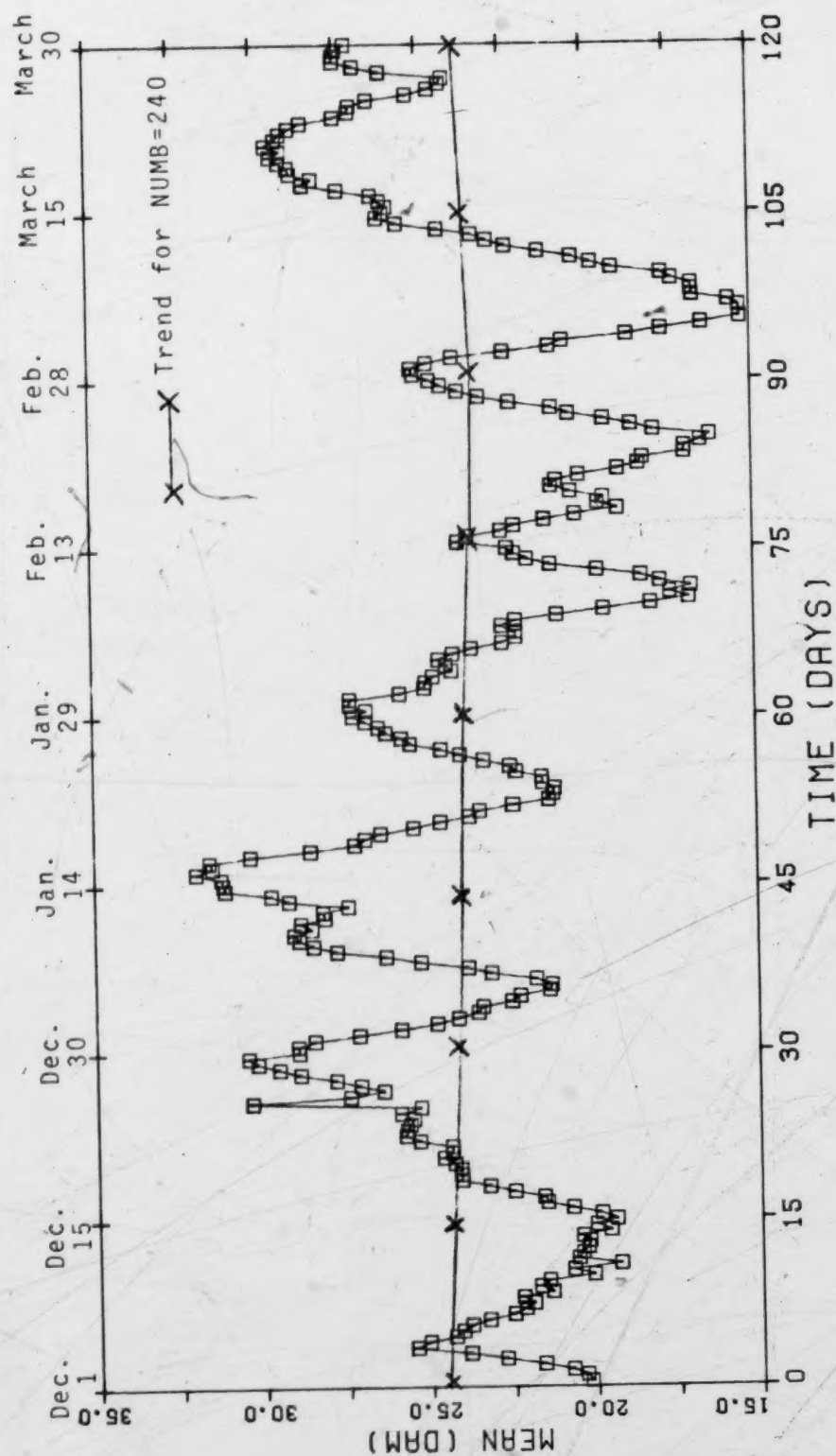
The program operated on the Northern Data set without any modifications. Unfortunately, the forecasts

Table 6.1. Values of Trend Coefficients and Mean and Variance Around the Trend, for Various Values of NUMB.

NUMB	D (dam)	H (dam)	C (dam)	MEAN	VARIANCE
5	66.7	-47.5	73.3	0.000	0.107
10	110.6	-91.8	93.6	0.000	0.192
15	-1232.9	1252.4	102.8	0.060	0.733
20	-907.1	927.1	81.2	0.065	0.791
25	-258.6	280.5	21.0	0.124	1.544
30	-196.0	217.9	16.6	0.113	1.466
35	0.7	21.9	-4.8	0.095	2.054
40	132.5	-109.4	-20.8	0.091	2.485
45	183.7	-160.2	-27.9	0.106	2.325
50	177.1	-153.7	-26.8	0.095	2.131
60	174.2	-151.0	-25.6	0.078	2.092
70	41.6	-20.5	4.9	0.045	5.502
80	13.0	7.5	11.7	0.035	6.237
90	32.4	-11.4	6.0	0.045	5.872
100	29.0	-8.1	7.3	0.058	6.025
110	-4.1	23.6	19.4	0.083	7.861
120	-0.2	19.9	17.7	-0.013	7.546
130	1.0	18.8	17.3	-0.007	7.063
140	-5.3	24.6	20.2	0.016	6.885
150	-8.6	27.7	21.8	0.019	7.040
160	-5.0	24.4	19.9	0.006	6.885
170	-4.8	24.2	18.8	0.005	6.566
180	1.6	18.6	15.8	-0.003	7.543
190	6.2	14.7	12.9	-0.011	8.271
200	5.6	15.2	13.3	-0.010	8.007
210	11.5	10.3	9.0	-0.009	9.778
220	18.1	5.0	3.9	0.030	12.964
230	22.9	1.2	0.1	0.024	14.412
240	24.8	-0.2	-1.5	0.023	14.247

Northern Data Set

Figure 6.1. Means of Reports and Trend for the Period December 1 00Z, 1976 to March 30 12Z, 1977.



did not verify as well as did those of the Southern Data set. Table 6.2 gives the values of r^* for several forecast options. These values are at least twice as large as those for the Southern Data set. Smoother No. 3 showed "increased skill" compared to the Climatology and Persistence forecasts while the unsmoothed time-waves showed "reduced skill".*

Part of the forecast error was due to a spring pattern shift, as can be seen in Figure 6.2. The trough near 100W longitude starts to break down and to drift eastward. However, some of the error was due to a poor trend calculation. The error in the mean started at 3 dam and increased to 8 dam after 28 forecasts, and to 15 dam by the end of the 60-report (30 day) forecast period.

The amplitudes of the waves (see Figure 6.3) were also larger in the Northern Data set than in the Southern set. The space-waves with wave numbers 1 and 2 were still the most important and had amplitudes as large as 20 dam. The wave amplitudes decrease as wave numbers increase so that the amplitudes are generally below 5 dam once the wave number is greater than five. For any constant wave number, the time fluctuations of amplitude indicates long time-waves that might be resolved in a larger data set.

* See Appendix N for actual forecast results.

Table 6.2. Statistics for Various Forecasts Made
Using the Northern Data Set with
NUMB = 240 and JWAVE = 8

	Smoother	NWAVE	$\bar{R}$	$\overline{MSEE}$	r^*
Persistence	--	--	0.323	126.9	143.8
Climatology	--	--	0.491	127.9	137.7
	NONE	2	0.482	137.1	146.6
		3	0.447	183.0	191.2
		1	0.483	111.3	122.7
	3	3	0.480	108.1	120.0
		5	0.488	116.0	126.8
		7	0.342	144.9	159.1

Figure 6.2. Hovmöller Diagram for the Period April 1 to 30, 1977
(Northern Data Set)

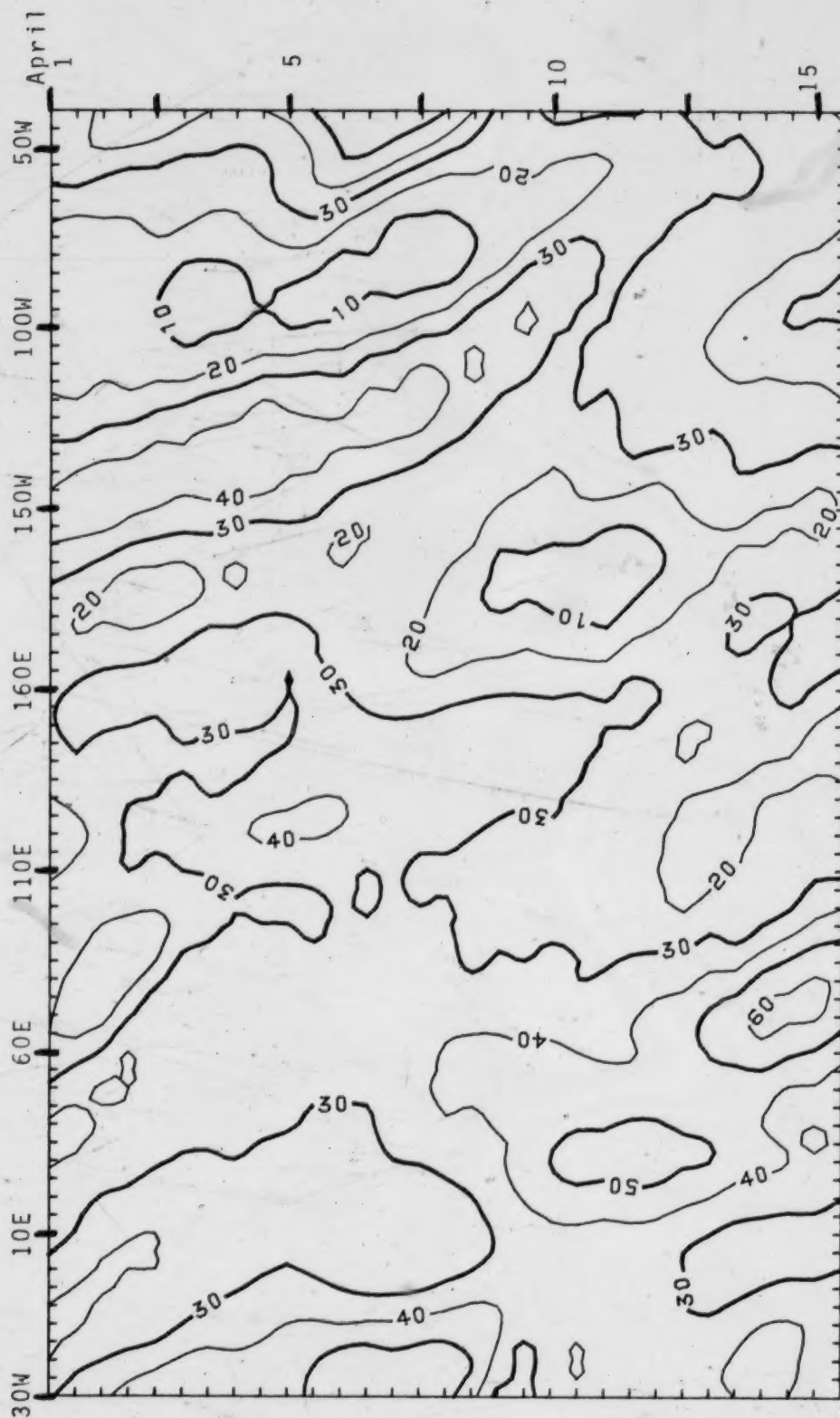
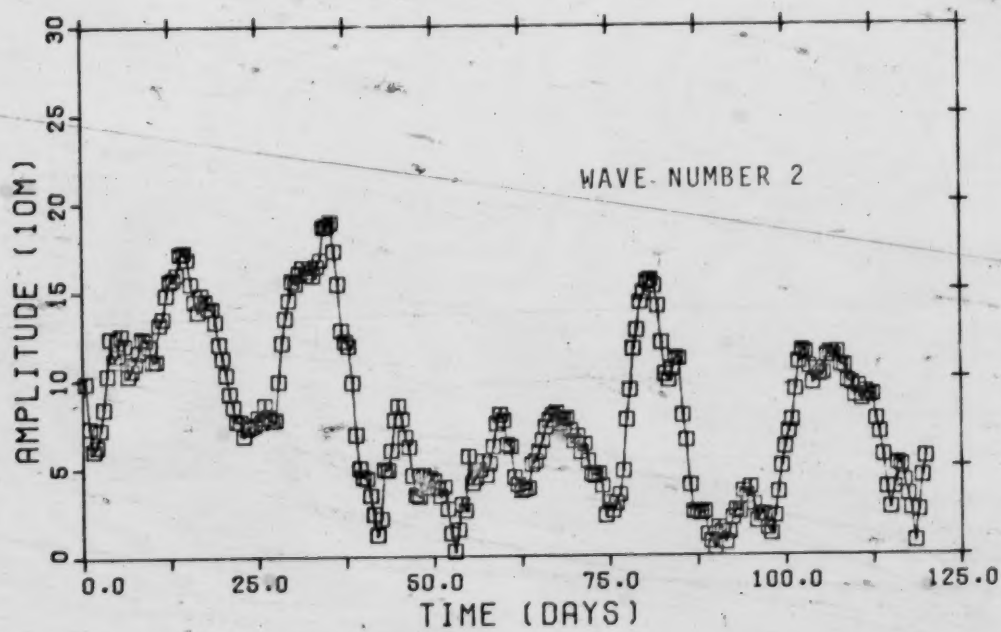
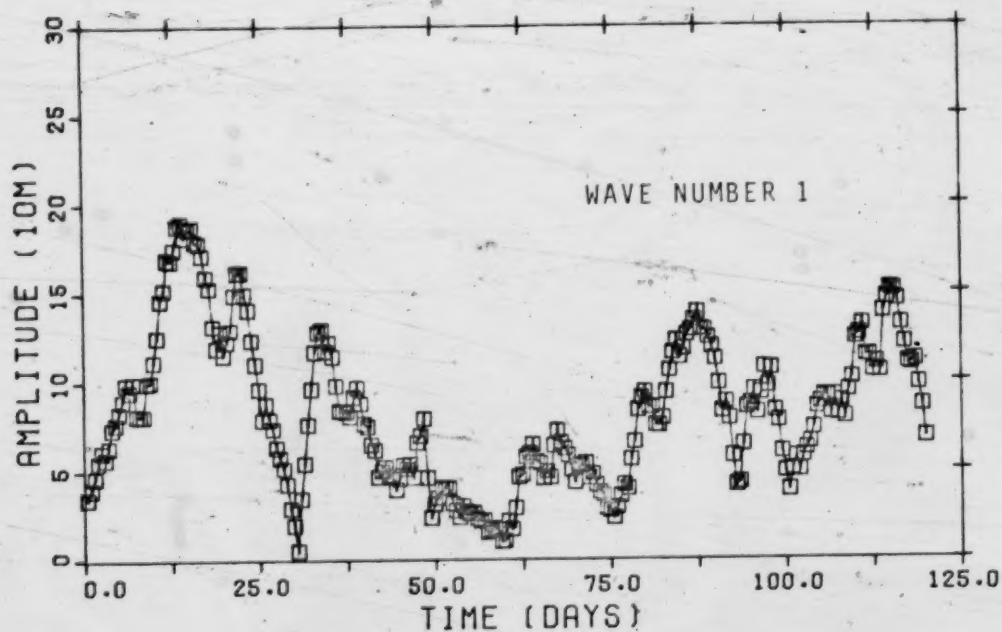


Figure 6.3. Plots of Amplitude Versus Time
for Two Space-waves.
Northern Data Set



CHAPTER 7

CONCLUSION

7.1 Summary of Results

Figure 7.1 shows the actual Hovmöller Diagram and Figure 7.2 shows the forecast diagram for the period March 23, 12Z to April 7, 12Z 1977, using the Southern Data set. The forecast was made with Smoother No. 3, NUMB = 240, JWAVE = 11, and NWAWE = 2. These diagrams are strikingly different. The forecast diagram is quite smooth, with the forecast ridges and troughs showing some resemblance to the actual ridges and troughs. However, this resemblance is not good enough to be used to make operational weather forecasts.

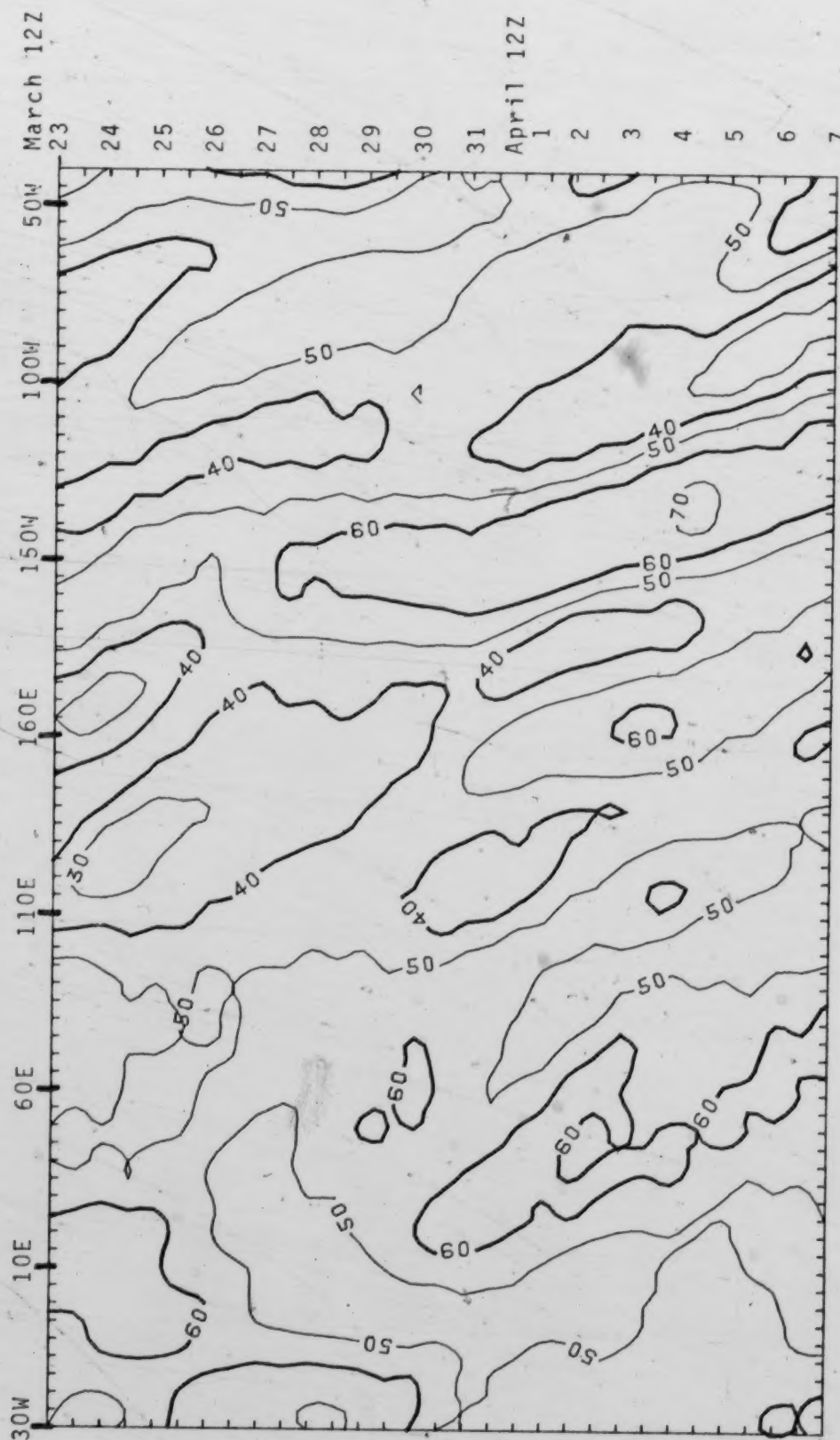
This forecast diagram does show some skill since it indicates three interesting features. These are:

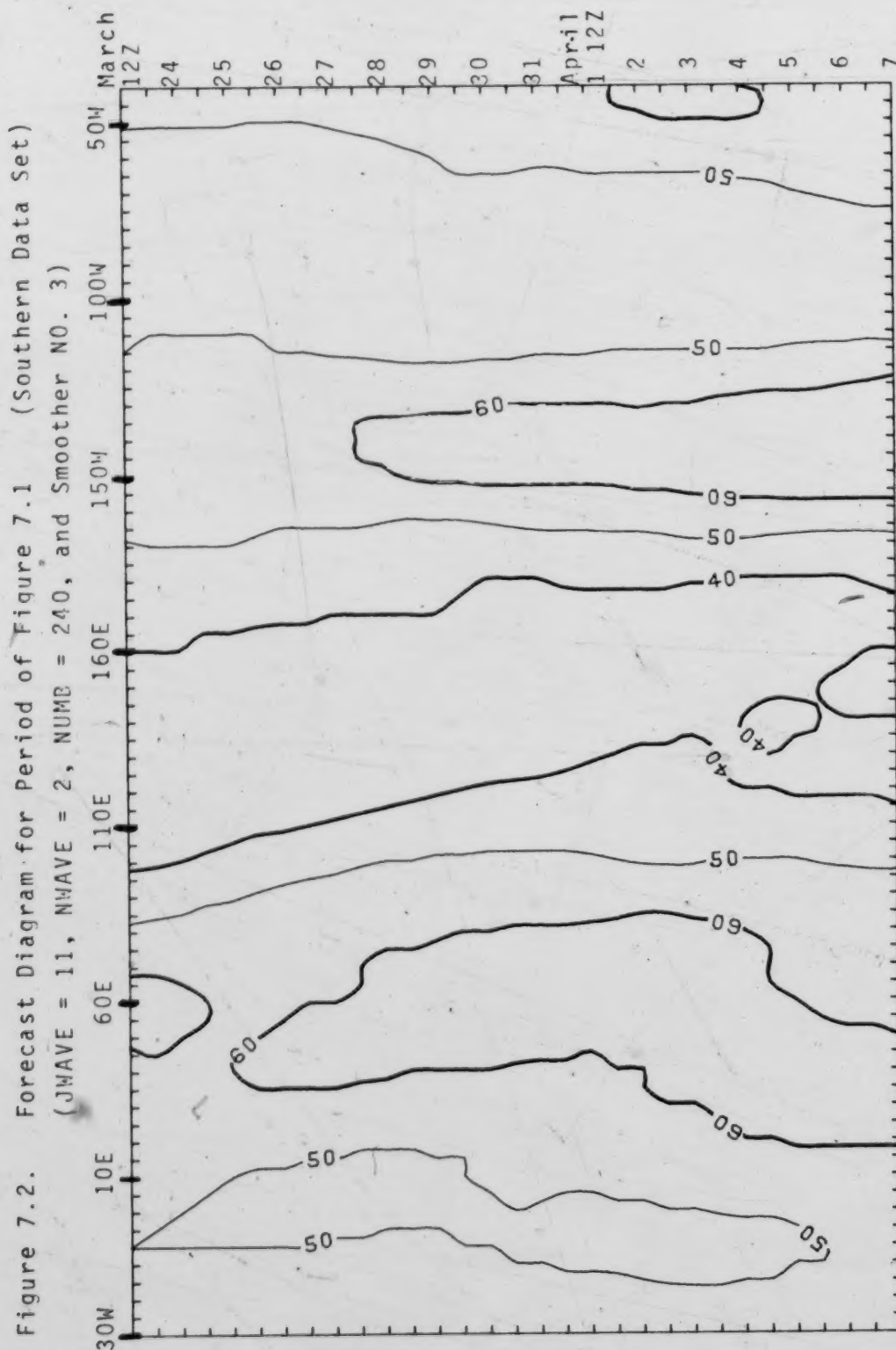
- 1) a stationary ridge along 140°W ,
- 2) a retrogressing ridge along 40°E ,
- and 3) a trough that splits into two troughs along 140°E .

As stated above, these features are slightly correlated with the actual height changes.

One of the things that is not observed in Figure 7.2 is the energy pulse. This might be due to

Figure 7.1. Hovmöller Diagram for March 23 12Z to April 7 12Z, 1977
(Southern Data Set)





the small number of time-waves used (NWAVE = 2); however, the use of more time waves produced smaller average correlation coefficients.

7.2 Future Studies

Oracheski is currently studying the results of converting the 500-mb height data that are presented in a Hovmöller Diagram. He first converts the data to "standardized" form. That is, for a report with elements X_i , a mean A_0 and variance σ^2 , the converted standardized report has elements $\frac{X_i - A_0}{\sigma^2}$, a mean of zero, and a variance of 1.00. The resulting data are then presented in the usual Hovmöller type diagrams.

Using this procedure, he has found that ridges and troughs appear more distinct. Also, a diurnal cycle is easily observed in the data throughout the year.

The height forecast program can be used to check if the standardization of the data produces better forecasts than the actual data. Better results are expected for forecasts of the standardized data since some of the "noise" would be removed. Also, since no trend would be observed, the error produced by the mean calculation would be removed. However, to reconvert the standardized data to 500-mb heights, the mean and the variance would also have to be forecast. The net effect

on forecast accuracy would have to be determined by experiments.

7.3 Larger Data Sets

The forecasts for the Southern Data set were good for NUMB = 240 and should get better as NUMB increases (maximum NUMB = 300). On the other hand, the forecasts for the Northern Data set were poor. To produce better forecasts a much larger data set is needed. From Figure 6.1, a long wave of period around 80 - 90 days, can be observed. This indicates that a Data Set close to one year in length (NUMB = 730) would be able to resolve this wave. The program would have to be adjusted to operate on such a large mass of data, but the results should be much better than those presented in this study.

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APPENDIX A

Derivation of the equation for the phase speed $V(m)$

Assume that the wave can be described by:

$$A(t)\cos(D(L,m)) + B(t)\sin(D(L,m))$$

$$A(t) = R_0 \cos(\phi(t))$$

$$B(t) = -R_0 \sin(\phi(t))$$

assume $\phi = \phi_0 + V(t-t_0)$

where t_0 , ϕ_0 refer to time zero (i.e. $t_0 = 0$)

therefore $A(t) = R_0 \cos(\phi_0 + Vt)$

$$= R_0 \cos(\phi_0) \cos(Vt) - R_0 \sin(\phi_0) \sin(Vt)$$

and similarly

$$B(t) = -R_0 \sin(\phi_0) \cos(Vt) - R_0 \cos(\phi_0) \sin(Vt)$$

At $t = t_0 = 0$

$$A(0) = R_0 \cos(\phi_0)$$

$$B(0) = -R_0 \sin(\phi_0)$$

therefore

$$A(t) = A_0 \cos(Vt) + B_0 \sin(Vt)$$

$$B(t) = B_0 \cos(Vt) - A_0 \sin(Vt)$$

Rearrange

$$\frac{A(t)}{B_0} = \frac{A_0}{B_0} \cos(Vt) + \sin(Vt)$$

$$\frac{B(t)}{A_0} = \frac{B_0}{A_0} \cos(Vt) - \sin(Vt)$$

therefore

$$\cos(Vt) = \left(\frac{A(t)}{B_0} + \frac{B(t)}{A_0} \right) / \left(\frac{A_0}{B_0} + \frac{B_0}{A_0} \right)$$

$$\cos(Vt) = \frac{A(t)A_0 + B(t)B_0}{A_0A_0 + B_0B_0}$$

similarly

$$\sin(Vt) = \frac{B_0A(t) - A_0B(t)}{A_0A_0 + B_0B_0}$$

therefore

$$V = \frac{1}{t} \arctangent \left(\frac{B_0A(t) - A_0B(t)}{B_0B(t) + A_0A(t)} \right)$$

APPENDIX B

TREND REMOVAL

Assume trend of form $Y'(I)$ where

$$Y'(I) = D + H \cos(X) + C \sin(X)$$

and where $X = \frac{I \cdot 2\pi}{730}$

so trend repeats after one year

therefore error = $Y(I) - Y'(I)$

therefore use least-squared technique and minimize

$$\sum_{I=1}^N (Y(I) - Y'(I))^2$$

$$(Y(I) - Y'(I))^2$$

$$\begin{aligned} &= Y^2(I) - HY(I)\cos(X) - CY(I)\sin(X) - DY(I) - \\ &\quad HY(I)\cos(X) + H^2\cos^2(X) + HC\cos(X)\sin(X) \\ &\quad + DH\cos(X) - CY(I)\sin(X) + HC\cos(X)\sin(X) \\ &\quad + C^2\sin^2(X) + CD\sin(X) - DY(I) + HD\cos(X) \\ &\quad + CD\sin(X) + D^2 \end{aligned}$$

$$= \text{Quant}$$

$$= D^2 + Y^2(I) - 2DY(I) + 2H(D-Y(I))\cos(X) + \\ 2C(D-Y(I))\sin(X) + H^2\cos^2(X) + C^2\sin^2(X) \\ + 2HC\cos(X)\sin(X)$$

take

$$\frac{\partial \text{Quant}}{\partial D}, \quad \frac{\partial \text{Quant}}{\partial H}, \quad \frac{\partial \text{Quant}}{\partial C} \quad \text{and set } = 0 \text{ for extremum}$$

$$\frac{\partial \text{Quant}}{\partial D} = 2D - 2Y(I) + 2H\cos(X) + 2C\sin(X) = 0$$

$$\frac{\partial \text{Quant}}{\partial H} = -2Y(I)\cos(X) + 2H\cos^2(X) + 2C\cos(X)\sin(X) \\ + 2D\cos(X) = 0$$

$$\frac{\partial \text{Quant}}{\partial C} = -2Y(I)\sin(X) + 2C\sin^2(X) + 2H\cos(X)\sin(X) \\ + 2D\sin(X) = 0$$

now added in

$$\begin{aligned} & \sum_{I=1}^N \\ 1 \left\{ \begin{aligned} & DN - \sum_{I=1}^N Y(I) + H \sum_{I=1}^N \cos(X) + C \sum_{I=1}^N \sin(X) = 0 \\ & - \sum_{I=1}^N Y(I)\cos(X) + H \sum_{I=1}^N \cos^2(X) + C \sum_{I=1}^N \cos(X)\sin(X) \\ & + D \sum_{I=1}^N \cos(X) = 0 \\ & - \sum_{I=1}^N Y(I)\sin(X) + C \sum_{I=1}^N \sin^2(X) + H \sum_{I=1}^N \cos(X)\sin(X) \\ & + D \sum_{I=1}^N \sin(X) = 0 \end{aligned} \right. \end{aligned}$$

now if data equally spaced & completes one full period,

$$\sum \cos(X) = \sum \sin(X) = \sum \cos(X)\sin(X) = 0$$

$$\sum \cos^2(X) = \sum \sin^2(X) = \frac{N}{2}$$

and the problem reduces to a Fourier type solution for one wave

$$\text{mean: } D = \frac{1}{N} \sum_{I=1}^N Y(I)$$

$$\text{amplitudes: } H = \frac{2}{N} \sum_{I=1}^N Y(I)\cos(X)$$

$$C = \frac{2}{N} \sum_{I=1}^N Y(I)\sin(X)$$

However, if data not equally spaced and one period not fully completed then the sums must be calculated.

$$\text{Call } \sum_{I=1}^N \cos(X) = T \quad \sum_{I=1}^N \sin(X) = W$$

$$\sum_{I=1}^N \cos^2(X) = P \quad \sum_{I=1}^N \sin^2(X) = Q$$

$$\sum_{I=1}^N \cos(X)\sin(X) = S$$

$$\text{and } \sum_{I=1}^N Y(I)\cos(X) = E$$

$$\sum_{I=1}^N Y(I) \sin(X) = F$$

$$\sum_{I=1}^N Y(I) = G$$

The set of equations (1) then reduces to

$$\begin{bmatrix} P & S & T \\ S & Q & W \\ T & W & N \end{bmatrix} \begin{bmatrix} H \\ C \\ D \end{bmatrix} = \begin{bmatrix} E \\ F \\ G \end{bmatrix}$$

using the Gauss-Jordan technique, the solution for H, C AND D becomes:

$$D = \frac{(TE-PG)(S^2-PQ) - (TS-PW)(SE-PF)}{(S^2-PQ)(T^2-PN) - (TS-PW)(TS-PW)}$$

$$C = \{(SE - PF) - (ST-PW) D\} / (S^2-PQ)$$

$$H = (E - TD - SC) / P$$

APPENDIX C

(Southern Data Set)

Figure C.1 to C.11

Amplitude versus Time for space-waves of wave number 1 to 11, respectively. Time is indicated as days after November 23, 1976.

Table C.1

Values of AAMPL for NUMB = 240

Table C.2

Values of BAMPL for NUMB = 240

Figure C.1:

Wave Number 1

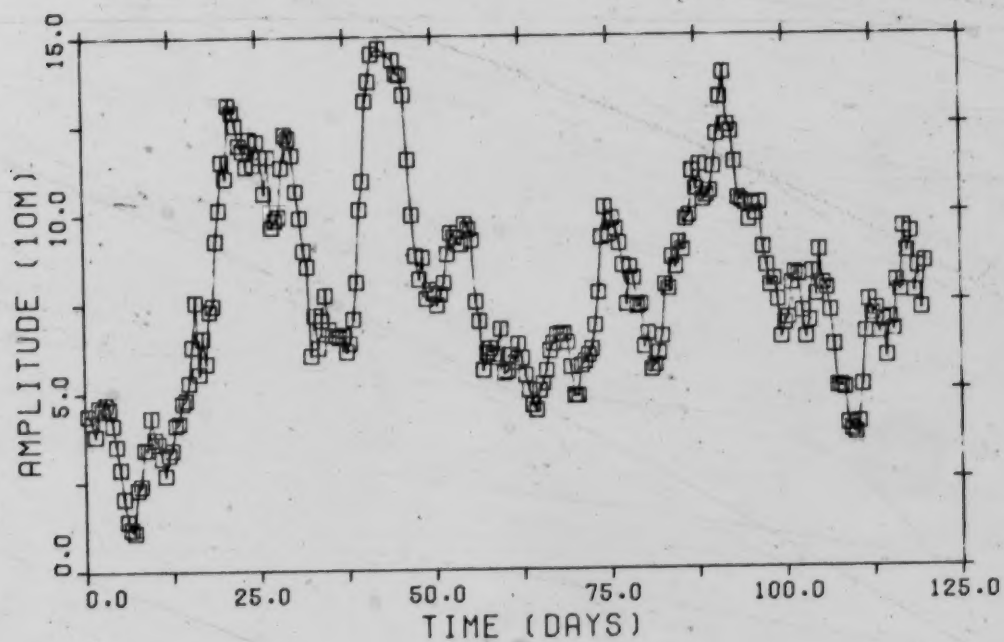


Figure C.2.

Wave Number 2

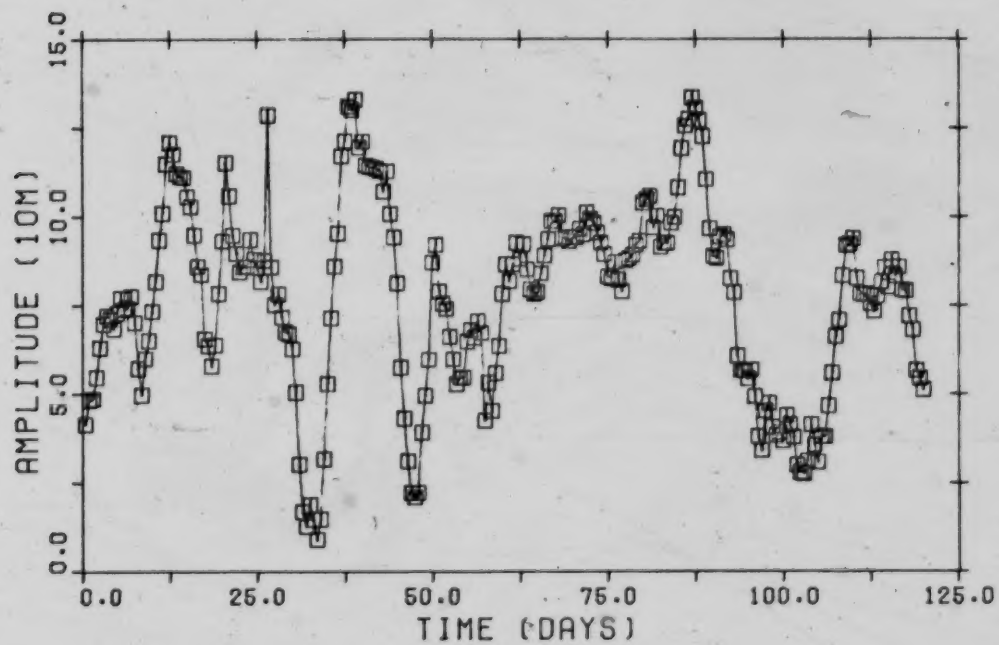


Figure C.3.

Wave Number 3

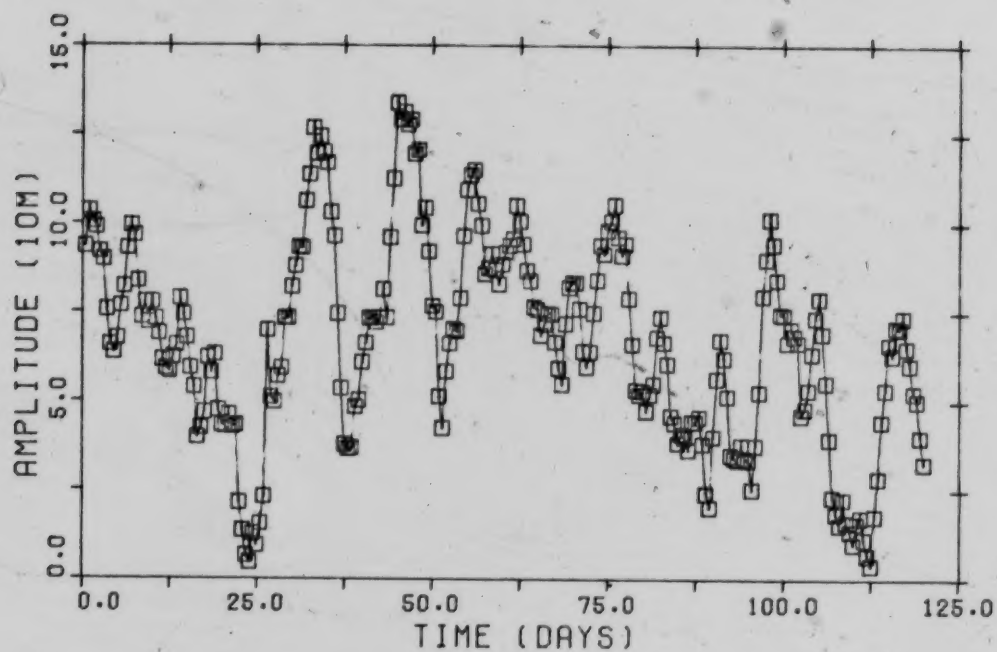


Figure C.4.

Wave Number 4

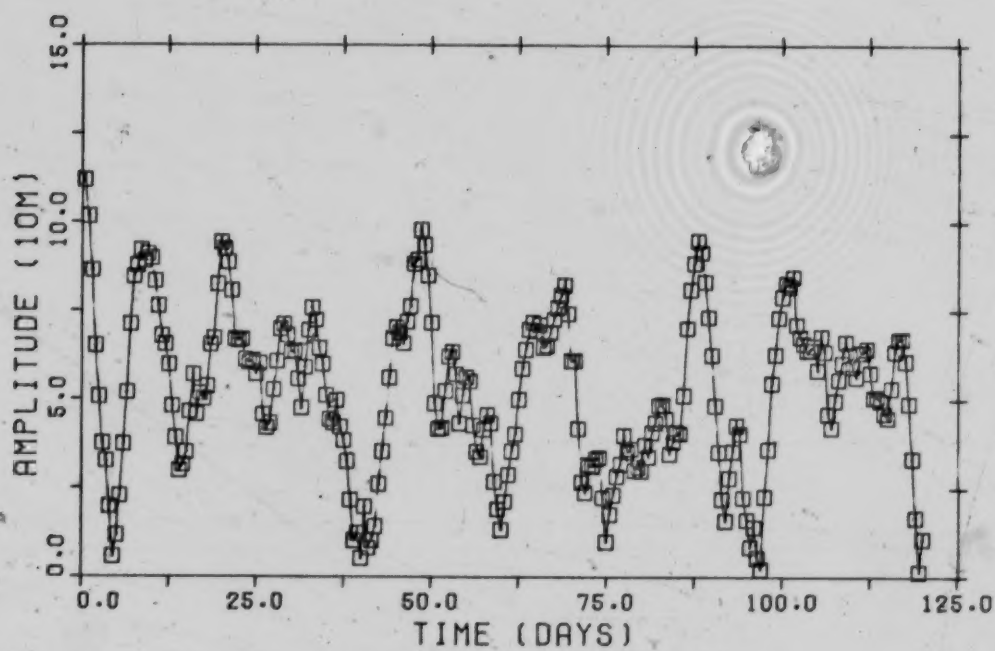


Figure C.5.

Wave Number 5

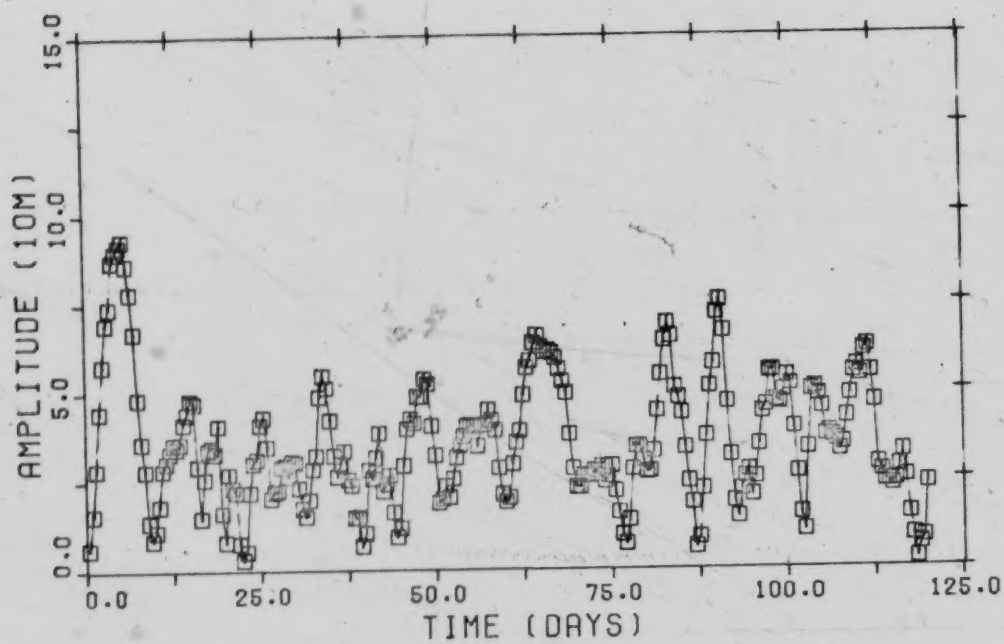


Figure C.6

Wave Number 6

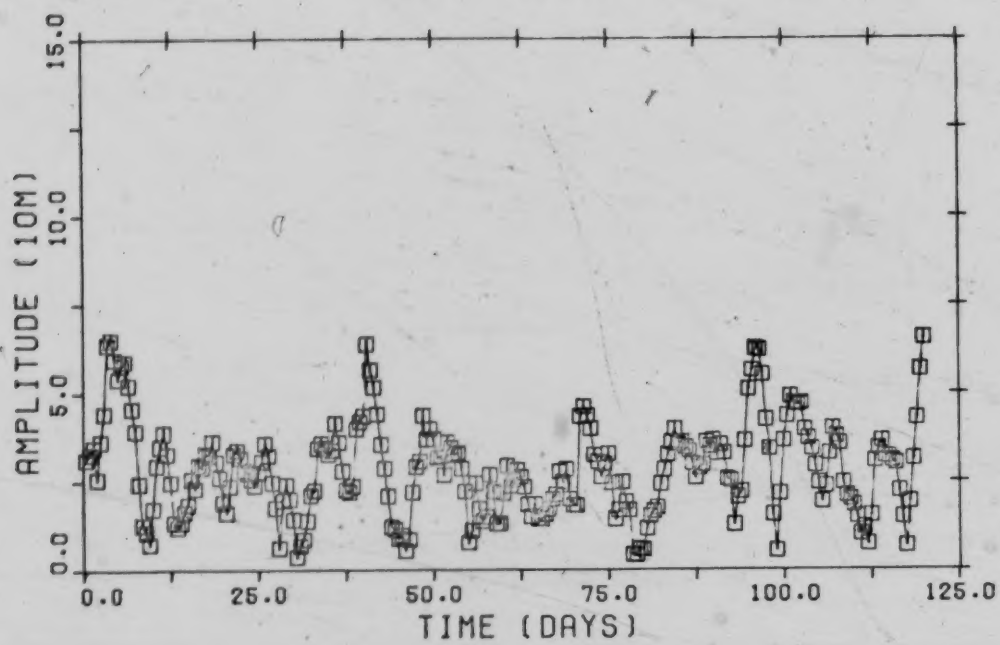


Figure C.7. Wave Number 7

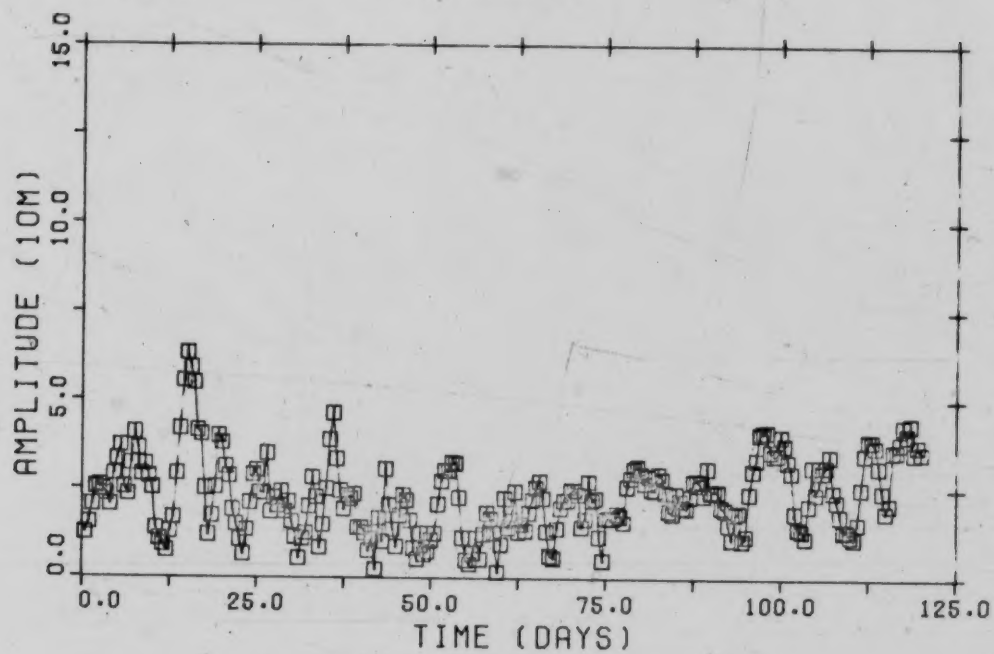


Figure C.8. Wave Number 8

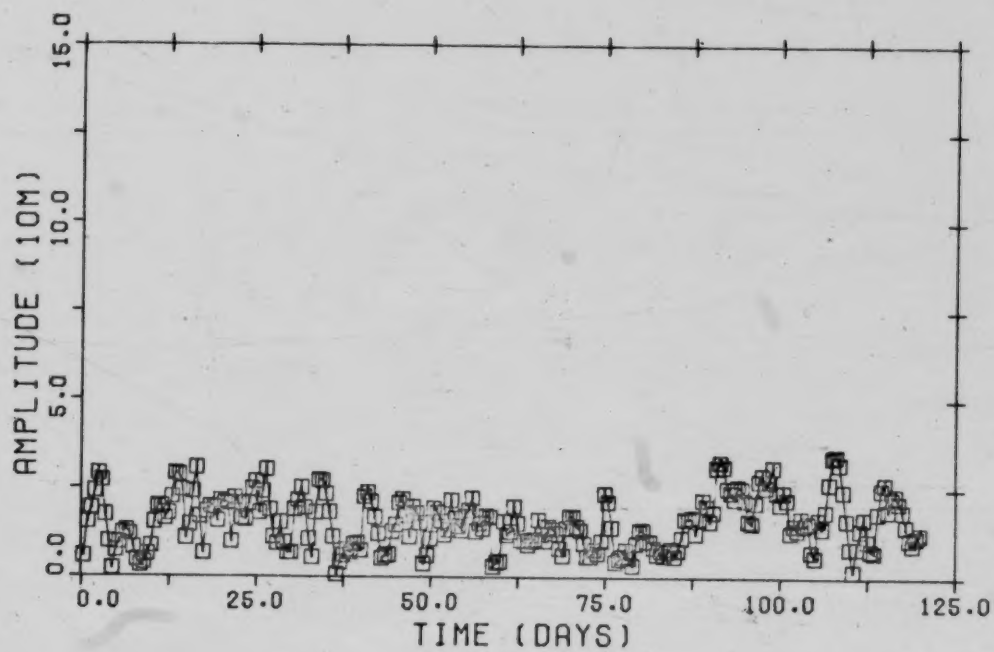


Figure C.9.

Wave Number 9

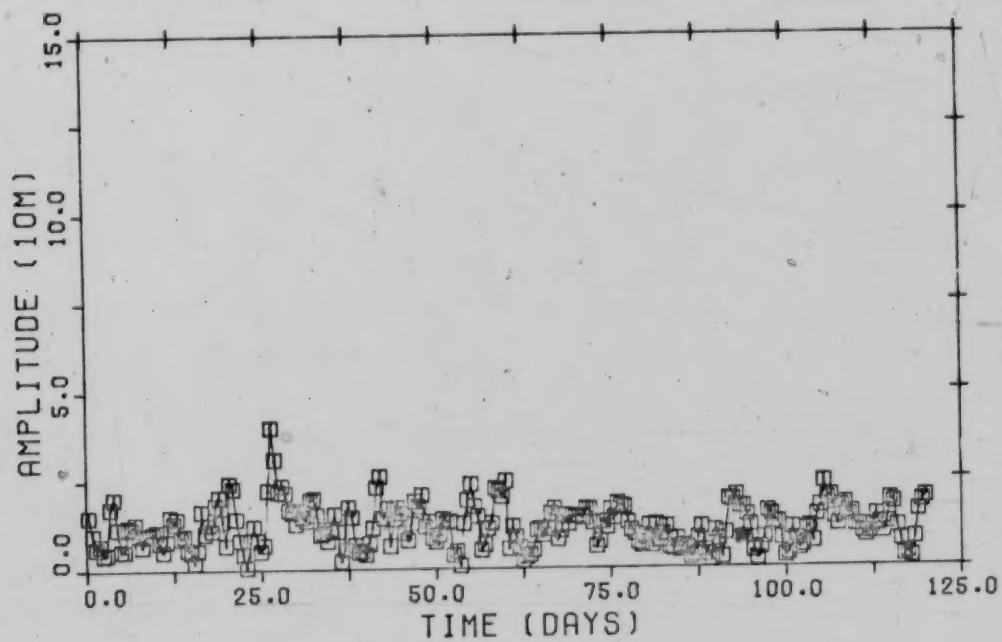


Figure C.10

Wave Number 10

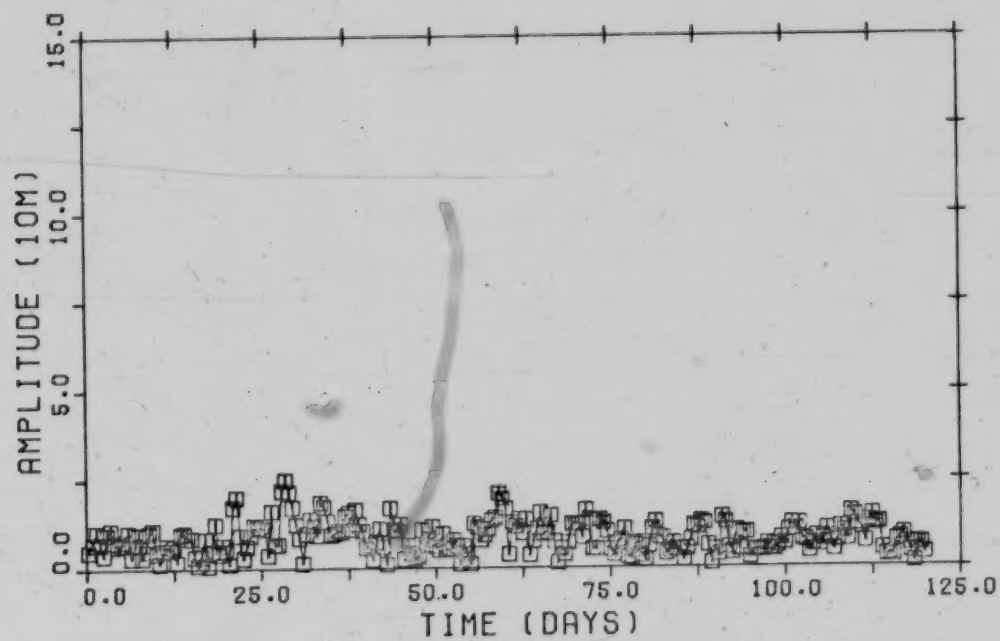


Figure C.11.

Wave Number 11

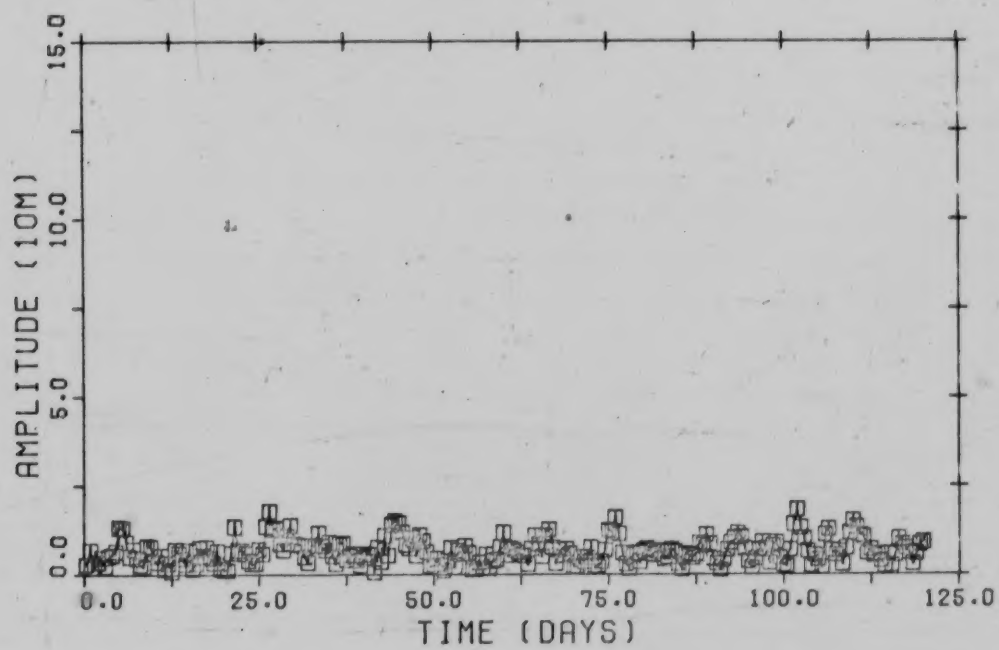


Table C.1. Values of AAMPL for NUMB = 240

Row	Wave Number										
	1	2	3	4	5	6	7	8	9	10	11
1	-2.17	-1.46	-4.60	4.15	0.18	-0.16	0.16	-0.26	-0.55	0.06	0.14
2	-1.64	-1.84	-5.13	3.40	0.77	-0.44	0.43	-0.72	-0.49	-0.07	0.32
3	-1.43	-1.87	-4.98	2.79	1.42	-0.66	0.57	-0.60	-0.15	0.38	0.10
4	-1.36	-2.20	-4.90	2.30	2.22	-0.35	0.34	-0.19	0.11	0.33	0.17
5	-1.75	-2.61	-4.55	1.86	2.85	-0.03	-0.21	0.51	0.14	0.17	0.22
6	-1.66	-3.30	-4.40	1.31	3.34	0.04	-0.60	1.03	-0.13	0.48	0.07
7	-2.05	-3.48	-3.60	1.17	3.45	-0.06	-0.83	0.87	0.13	0.17	-0.01
8	-1.80	-3.38	-3.10	0.54	3.89	-0.43	-0.63	0.34	0.91	-0.27	0.21
9	-1.69	-3.12	-2.86	0.25	3.51	-0.80	-1.14	-0.04	0.53	-0.26	-0.25
10	-1.23	-3.08	-2.98	-0.0	2.51	-0.97	-1.61	0.35	0.22	0.32	0.21
11	-1.02	-2.84	-3.34	0.55	1.25	-1.50	-1.83	0.17	0.17	0.38	0.65
12	-0.52	-2.20	-3.65	1.06	0.21	-2.06	-1.12	-0.28	-0.51	0.49	0.36
13	-0.52	-1.90	-4.07	1.55	-0.55	-2.33	-1.01	-0.65	-0.50	0.11	0.16
14	-0.49	-2.12	-4.19	2.42	-1.07	-2.18	-1.23	-0.44	-0.40	0.26	0.16
15	-1.02	-2.34	-3.98	3.27	-1.22	-1.96	-1.06	0.20	-0.02	0.48	-0.14
16	-0.79	-2.54	-3.64	3.53	-1.20	-1.10	-0.20	0.18	-0.32	0.14	-0.13
17	-0.26	-2.45	-3.56	3.88	-1.04	-0.30	0.73	0.02	-0.48	0.25	0.07
18	0.53	-2.99	-3.87	3.49	-0.64	0.21	1.40	-0.19	0.02	0.42	-0.07
19	1.28	-3.24	-3.60	3.55	-0.36	0.27	1.41	-0.29	0.42	0.0	-0.38
20	1.40	-3.64	-3.86	3.24	-0.55	0.74	1.09	0.25	0.51	-0.07	-0.15
21	1.65	-3.95	-3.63	2.98	-0.71	1.47	0.05	0.76	0.15	-0.04	0.17
22	1.59	-4.42	-3.39	2.43	-0.51	1.53	-0.47	0.75	-0.01	0.25	-0.11
23	1.35	-4.74	-2.86	1.94	0.32	1.09	-0.39	-0.15	0.35	0.16	-0.02
24	1.29	-5.45	-2.64	1.53	0.82	0.51	-0.19	-0.69	0.59	-0.05	-0.01
25	1.22	-5.75	-2.44	1.33	1.60	0.12	-0.33	-0.77	0.11	0.08	-0.01
26	1.01	-5.65	-2.66	0.96	1.73	-0.23	-0.30	0.02	-0.46	-0.09	0.31
27	0.77	-5.24	-2.85	0.76	1.71	-0.59	-0.08	0.94	-0.43	0.43	0.24
28	0.77	-4.91	-3.38	0.71	1.64	-0.59	0.85	1.37	-0.16	0.45	0.23
29	-0.35	-4.60	-3.27	1.05	1.52	-0.14	2.45	1.11	0.29	-0.25	-0.15

Table C.1. cont'

30	-1.22	-3.90	-3.04	1.52	1.12	0.21	3.10	0.20	-0.06	-0.38	0.31
31	-2.16	-3.35	-2.61	2.31	0.78	0.69	1.91	-0.71	-0.04	0.04	-0.04
32	-2.63	-2.64	-2.68	2.73	0.34	1.00	-0.26	-0.69	0.09	-0.03	-0.09
33	-2.25	-2.29	-1.80	1.98	0.31	1.33	-1.77	0.01	-0.44	0.12	0.36
34	-2.46	-2.96	-1.77	2.02	1.21	0.16	-1.95	0.79	-0.50	0.40	-0.22
35	-1.85	-2.07	-1.65	2.10	1.61	-0.67	-0.61	-0.17	-0.19	0.01	-0.36
36	-2.20	-1.93	-2.11	2.39	1.63	-1.05	0.10	-0.90	0.52	-0.08	0.07
37	-2.04	-2.03	-1.70	2.99	1.60	-1.10	0.45	-0.85	0.44	-0.10	-0.01
38	-2.84	-2.36	-2.44	3.33	2.01	-0.77	1.03	-0.65	0.05	0.05	-0.27
39	-3.52	-3.23	-1.50	4.01	0.66	-0.90	2.00	-0.76	-0.34	0.29	0.01
40	-4.11	-3.89	-1.36	4.57	-0.05	-0.39	1.52	-0.88	-0.11	0.17	-0.01
41	-4.42	-4.38	-1.47	4.59	-0.0	0.79	0.76	-0.08	-0.18	-0.02	0.06
42	-5.00	-4.11	-1.37	4.25	-0.76	-0.10	-1.26	0.40	-0.98	0.64	0.31
43	-5.07	-4.08	0.55	3.30	-0.75	-1.42	-0.19	0.46	-0.66	0.41	-0.55
44	-5.20	-3.37	-0.91	3.32	-0.14	-1.59	-0.15	0.40	-0.29	0.14	-0.32
45	-5.32	-3.20	-0.39	3.30	-0.04	-1.55	0.51	0.89	0.09	0.14	-0.33
46	-5.14	-3.54	-0.42	3.32	0.07	-1.22	0.33	0.71	-0.02	0.29	-0.23
47	-5.00	-3.59	-0.28	3.05	-0.16	-0.81	0.50	-0.32	-0.39	-0.22	-0.17
48	-5.17	-3.73	-0.16	3.01	-0.65	0.04	0.35	-1.02	-0.43	-0.60	-0.10
49	-5.31	-2.88	0.26	3.04	-0.99	0.72	-0.13	-0.65	0.02	-0.14	0.13
50	-5.86	-2.83	0.35	2.85	-1.74	1.37	-0.97	0.12	0.16	0.56	0.16
51	-5.81	-2.09	-0.70	2.56	-1.55	1.42	-0.19	-0.36	0.34	0.43	0.28
52	-5.27	-2.91	0.30	2.27	-1.63	1.51	-1.17	1.16	-0.78	0.05	-0.67
53	-5.61	-5.03	-0.25	2.09	-0.47	-0.21	0.38	0.92	-1.68	0.67	0.56
54	-4.72	-2.67	-0.44	1.96	-0.79	0.46	0.14	0.71	-1.23	0.29	0.43
55	-4.73	-2.12	-1.43	1.73	0.03	-0.15	0.54	0.42	-0.70	0.20	0.60
56	-4.61	-2.44	-1.69	2.03	-0.10	-0.11	1.02	-0.45	0.18	-0.22	-0.40
57	-5.31	-2.10	-2.18	2.51	-0.03	0.11	1.00	-0.12	1.01	-1.07	0.01
58	-5.60	-2.18	-2.98	2.64	0.14	0.74	0.62	0.29	0.62	-0.98	0.53
59	-5.45	-1.89	-2.86	2.82	0.51	0.67	0.39	0.33	-0.26	-0.20	0.41
60	-5.16	-1.58	-3.38	2.67	0.57	0.43	0.33	-0.32	-0.62	0.36	-0.15
61	-4.96	-0.93	-3.94	2.91	0.59	-0.15	0.16	-0.74	-0.36	0.38	-0.42
62	-4.58	-0.42	-4.37	2.67	0.73	-0.28	-0.25	-0.54	0.39	-0.04	-0.27
63	-4.37	0.10	-4.57	2.36	0.75	-0.30	0.04	0.23	0.65	-0.48	-0.04
64	-4.07	0.30	-5.27	2.91	0.93	-0.32	0.53	0.58	0.38	-0.68	-0.10

Table C.1. cont'

65	-2.95	0.30	-5.68	3.34	0.77	-0.87	1.00	0.49	-0.49	-0.45	0.41
66	-3.52	0.19	-6.33	3.57	0.71	-1.04	1.37	-0.10	-0.55	-0.01	0.36
67	-3.06	-0.22	-5.91	3.25	0.0	-1.70	0.77	-0.82	-0.04	0.88	-0.37
68	-3.35	-0.72	-6.07	2.81	-1.01	-1.74	-0.20	-0.72	0.23	0.13	-0.24
69	-3.81	-1.58	-5.84	2.75	-1.36	-1.64	-0.55	0.24	0.39	-0.50	0.28
70	-3.29	-2.64	-5.69	2.46	-1.08	-1.48	0.01	1.05	-0.10	-0.40	0.39
71	-3.27	-3.56	-4.92	2.20	-0.55	-1.15	1.48	0.90	-0.45	-0.08	0.20
72	-3.25	-4.29	-4.47	1.92	0.09	-0.96	2.16	0.53	-0.52	-0.03	0.13
73	-3.24	-4.75	-3.42	1.92	0.66	-0.37	1.68	-0.0	-0.09	-0.28	0.41
74	-3.18	-5.85	-2.59	1.31	0.91	-0.06	1.07	-0.15	-0.04	-0.41	0.43
75	-2.99	-6.03	-1.86	0.72	0.65	0.29	0.36	-0.13	-0.27	-0.35	0.09
76	-2.82	-6.49	-1.80	0.34	0.47	0.80	0.08	-0.12	-0.50	0.31	-0.23
77	-3.18	-6.40	-1.68	0.40	-0.34	1.10	-0.29	0.04	-0.22	0.66	-0.11
78	-3.10	-6.37	-2.06	0.30	-0.73	1.88	-0.78	0.10	0.23	0.17	0.21
79	-4.30	-5.54	-2.05	0.58	-0.05	2.04	-0.49	0.44	-0.25	0.48	0.12
80	-4.42	-5.35	-2.40	0.24	0.12	2.10	-0.60	0.16	-0.20	0.14	0.22
81	-5.37	-4.64	-2.46	0.76	0.30	2.94	-0.63	0.85	-0.25	0.31	0.27
82	-5.73	-4.30	-2.71	0.16	0.98	2.32	-0.38	0.22	-0.57	0.10	0.24
83	-6.56	-4.10	-2.51	0.50	1.51	1.68	-0.52	-0.36	-0.47	0.36	0.02
84	-7.35	-4.20	-2.14	0.54	1.92	1.12	-0.05	-0.66	0.29	0.49	0.36
85	-7.00	-3.95	-2.82	0.87	1.04	1.16	-0.62	-0.35	-0.33	-0.17	0.15
86	-7.40	-3.80	-3.21	1.26	1.11	0.80	-0.47	-0.14	-0.13	-0.03	0.53
87	-7.49	-3.83	-3.05	1.19	0.55	0.62	-0.76	-0.30	-0.21	-0.73	0.22
88	-7.42	-3.38	-4.29	1.92	0.18	0.43	-0.89	0.31	-0.52	-0.51	0.67
89	-7.09	-2.96	-5.09	2.67	0.38	0.11	-0.69	0.34	-0.45	0.15	0.63
90	-6.82	-2.38	-6.06	3.14	0.52	-0.27	-0.44	-0.32	-0.11	0.60	-0.12
91	-6.96	-1.12	-6.40	2.58	1.22	-0.30	0.24	-0.59	0.29	0.06	0.08
92	-6.65	-1.12	-6.20	2.96	1.95	-0.24	-0.99	-1.05	0.18	0.05	-0.42
93	-5.75	-0.79	-6.21	3.29	2.11	0.41	-1.09	-0.53	-0.04	-0.0	-0.32
94	-4.96	-0.39	-6.40	3.43	1.88	1.07	-0.81	-0.13	-0.36	-0.01	0.15
95	-4.39	-0.97	-5.97	3.84	2.31	1.39	-0.42	0.99	-0.75	-0.07	0.25
96	-4.06	-1.09	-6.03	3.21	1.86	1.52	-0.21	0.81	-0.99	0.44	-0.01
97	-4.27	-1.90	-4.93	2.79	1.14	2.14	-0.42	0.33	-0.38	0.17	-0.47
98	-3.58	-2.44	-5.20	2.48	1.07	1.82	-0.31	0.16	-0.32	-0.24	0.09
99	-3.77	-2.97	-4.60	2.16	0.42	1.98	-0.01	-0.06	0.10	-0.55	0.09

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100	-3.67	-4.33	-3.80	1.47	-0.07	1.83	-0.05	-0.51	0.35	-0.18	-0.01
101	-3.66	-4.37	-3.58	0.22	-0.41	1.53	0.31	-0.92	0.46	0.08	-0.14
102	-3.04	-3.80	-2.39	1.06	-0.70	1.33	-1.03	-0.74	0.45	0.36	0.06
103	-3.09	-3.72	-1.50	1.40	-0.30	0.68	-1.23	-0.32	-0.06	0.08	-0.06
104	-3.53	-3.57	-1.12	2.03	0.46	0.90	-1.03	0.06	-0.44	0.02	-0.08
105	-4.11	-3.03	-0.94	2.35	1.11	0.84	0.04	0.67	-0.15	0.31	-0.11
106	-4.09	-2.74	-1.33	2.32	1.29	0.79	0.63	0.66	-0.20	0.12	0.09
107	-4.31	-2.23	-1.18	2.21	1.19	0.30	0.68	0.01	0.01	-0.0	0.19
108	-4.22	-2.29	-1.40	2.05	0.95	-0.06	0.26	-0.57	0.61	0.19	0.10
109	-4.67	-2.43	-0.96	2.55	0.73	-0.26	0.09	-0.65	0.95	0.19	-0.24
110	-4.72	-2.88	-1.46	2.76	0.41	-0.34	-0.0	-0.85	0.96	-0.01	-0.31
111	-4.61	-3.01	-1.92	2.72	0.05	0.02	0.19	-0.92	0.26	0.14	-0.07
112	-3.73	-2.81	-2.54	2.13	-0.27	0.59	-0.27	-1.02	-0.47	0.15	-0.04
113	-3.20	-2.08	-4.09	1.61	0.35	0.55	0.21	-0.58	-0.05	0.36	0.04
114	-2.76	-1.94	-4.04	1.51	0.32	0.21	0.09	-0.43	0.27	-0.04	0.07
115	-3.04	-1.35	-3.34	1.92	0.23	0.07	0.08	0.14	0.40	-0.50	-0.16
116	-3.08	-2.21	-2.89	2.28	-0.43	0.71	-0.54	0.39	-0.07	0.16	0.09
117	-2.96	-1.97	-2.19	2.14	-0.79	0.70	-0.61	0.58	-0.95	0.62	0.19
118	-2.98	-2.66	-1.48	1.33	-0.51	0.36	-0.61	0.15	-1.03	0.96	0.02
119	-3.37	-3.02	-0.81	0.84	0.09	0.31	-0.08	0.20	-0.54	0.31	-0.38
120	-2.74	-3.86	-0.51	0.66	0.79	1.05	-0.02	0.12	0.36	-0.27	0.20
121	-2.78	-4.16	-0.86	0.58	1.00	1.17	-1.12	0.44	0.21	-0.11	0.10
122	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
123	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
124	-3.16	-4.38	-2.31	0.36	1.94	-0.51	-0.85	-0.85	-0.06	0.06	0.27
125	-2.94	-4.07	-2.67	0.63	2.33	-0.78	-0.14	-0.75	-0.05	0.30	0.24
126	-2.72	-3.99	-3.22	0.52	2.55	-1.04	0.45	-0.50	0.15	0.65	0.03
127	-2.49	-3.28	-3.59	1.00	2.16	-0.87	0.64	-0.47	0.09	0.16	0.14
128	-2.24	-2.55	-3.94	1.48	1.67	-0.74	0.86	-0.43	0.01	-0.35	0.30
129	-2.15	-2.17	-3.73	2.32	1.23	-0.59	0.43	-0.42	0.15	-0.47	0.55
130	-2.26	-2.22	-3.77	2.74	0.44	-0.24	-0.21	-0.40	-0.16	-0.25	0.40
131	-2.52	-2.34	-3.40	3.17	-0.06	-0.34	-0.54	-0.45	-0.46	0.29	0.15
132	-2.74	-2.81	-3.58	2.73	-0.62	-0.77	-0.75	-0.09	0.01	0.47	0.51
133	-3.07	-3.16	-3.72	2.60	-1.08	-0.70	-0.65	0.22	0.06	0.72	0.18
134	-3.17	-3.42	-3.71	2.58	-1.23	-0.52	-0.24	0.18	0.47	0.34	-0.33

Table C.1. cont.

135	-3.29	-3.47	-3.28	2.87	-1.27	-0.0	-0.17	0.35	0.37	0.06	-0.14
136	-3.30	-3.62	-2.87	3.08	-1.32	0.53	-0.10	0.48	0.24	-0.19	0.04
137	-3.30	-3.33	-2.24	3.62	-1.35	0.97	-0.32	0.38	-0.31	-0.01	0.09
138	-3.16	-3.42	-2.31	3.77	-1.13	1.31	-0.48	0.03	-0.60	0.17	0.03
139	-2.83	-3.85	-2.06	3.46	-0.98	0.99	-0.83	-0.53	-0.16	0.57	0.28
140	-2.31	-4.09	-1.86	2.79	-0.80	0.58	-1.16	-0.85	0.46	0.37	-0.02
141	-2.31	-4.09	-1.86	2.79	-0.80	0.58	-1.16	-0.85	0.46	0.37	-0.02
142	-2.51	-4.67	-1.06	2.04	-0.20	-0.03	-1.16	-0.57	0.04	-0.38	0.05
143	-2.73	-4.54	-0.65	1.33	-0.23	-0.78	-0.65	-0.18	-0.71	0.13	0.11
144	-2.65	-4.75	-0.46	1.18	-0.02	-1.04	0.07	0.25	-0.70	0.62	-0.15
145	-2.94	-4.60	-0.36	1.56	0.34	-1.40	1.00	0.20	-0.17	0.08	-0.10
146	-3.31	-4.58	-0.41	1.55	0.48	-1.46	1.07	0.14	-0.22	0.13	-0.05
147	-3.79	-4.48	-0.54	1.59	0.71	-1.52	1.07	0.20	-0.25	0.04	0.05
148	-4.51	-4.25	-1.77	1.59	0.11	-1.21	0.21	0.03	-0.63	0.60	-0.16
149	-5.03	-4.06	-1.96	1.11	-0.45	-1.36	-0.13	-0.29	0.12	0.11	0.04
150	-4.68	-3.74	-2.93	0.25	-1.06	-1.26	-0.37	0.14	0.81	0.15	0.43
151	-4.90	-3.85	-3.00	0.05	-0.93	-0.28	-0.20	0.81	0.42	0.17	-0.57
152	-4.77	-4.21	-2.95	0.08	-0.48	0.54	0.41	0.69	-0.79	0.15	-0.46
153	-4.54	-3.99	-2.49	0.30	-0.14	0.73	0.66	0.0	-0.83	-0.17	0.24
154	-4.25	-3.83	-2.08	0.54	0.23	0.06	0.71	-0.18	-0.72	-0.53	0.27
155	-3.57	-4.19	-2.16	1.38	0.63	0.02	0.77	-0.26	-0.29	-0.14	-0.15
156	-4.18	-4.40	-1.71	1.43	1.37	-0.34	1.14	-0.34	0.04	0.06	-0.07
157	-4.08	-4.46	-1.44	1.46	1.63	-0.08	1.01	-0.06	0.40	-0.04	-0.20
158	-3.68	-4.56	-1.56	1.29	1.56	0.21	0.23	-0.12	0.33	-0.23	0.07
159	-3.67	-4.59	-1.56	1.48	1.19	0.20	-1.00	-0.41	0.31	-0.16	0.16
160	-3.05	-5.12	-1.76	1.49	1.05	0.28	-1.47	-0.08	0.43	0.03	-0.07
161	-3.21	-5.13	-1.50	1.85	0.81	0.58	-1.20	0.36	0.20	-0.13	-0.32
162	-2.79	-5.24	-1.57	1.69	1.11	0.74	-1.03	0.49	-0.22	-0.49	0.18
163	-2.86	-4.82	-1.57	2.02	1.36	0.82	-0.72	0.37	-0.60	-0.40	0.02
164	-2.90	-5.01	-1.88	2.13	1.77	0.75	-0.39	0.04	-0.22	0.19	-0.21
165	-3.21	-4.57	-1.86	2.31	1.70	0.83	0.39	-0.23	0.16	0.35	-0.33
166	-3.80	-4.63	-1.77	2.28	1.09	0.54	0.83	-0.17	0.55	0.14	-0.21
167	-3.87	-4.63	-1.57	2.15	0.52	0.20	0.95	-0.04	0.26	0.15	0.22
168	-4.30	-4.90	-1.74	1.64	-0.73	-0.25	0.94	-0.14	-0.14	0.32	0.36
169	-4.10	-4.93	-1.49	1.76	-0.90	-0.97	0.86	0.16	0.19	0.25	0.32

Table C.1. cont'

170	-4.03	-5.31	-1.47	1.96	-1.33	-1.40	1.19	0.02	0.24	0.11	0.14
171	-3.84	-5.77	-1.54	1.94	-1.47	-1.72	1.05	-0.25	0.17	-0.10	-0.06
172	-3.93	-6.06	-1.55	2.47	-1.20	-1.72	0.61	-0.31	0.01	-0.05	0.11
173	-3.91	-6.10	-0.97	3.50	-0.92	-1.68	-0.65	-0.21	-0.08	0.34	0.20
174	-4.21	-6.42	-0.77	4.04	-0.30	-1.48	-1.11	0.11	-0.17	0.47	-0.20
175	-4.35	-6.35	-0.41	4.39	0.18	-1.28	-0.74	0.41	-0.24	-0.05	-0.02
176	-4.46	-6.24	-0.25	4.69	0.65	-1.42	-0.02	0.52	0.30	-0.53	0.45
177	-4.40	-6.03	-0.19	4.52	0.76	-1.29	0.96	0.75	0.22	-0.60	0.13
178	-4.63	-5.41	-0.55	4.11	0.59	-1.03	1.14	0.67	0.08	-0.27	-0.48
179	-4.88	-4.69	-0.98	3.57	0.07	-0.47	1.55	0.16	0.10	-0.05	-0.41
180	-5.21	-4.20	-1.92	3.11	-0.68	-0.05	0.96	-0.48	0.11	0.03	-0.21
181	-5.79	-3.94	-2.67	2.41	-1.52	0.42	0.28	-0.75	-0.14	0.07	-0.13
182	-6.26	-3.76	-3.31	1.72	-2.32	0.78	-0.71	0.19	0.01	0.68	-0.06
183	-6.76	-3.58	-3.10	0.87	-2.15	1.03	-0.82	1.34	0.02	0.36	-0.17
184	-5.95	-3.96	-2.55	-0.34	-1.53	0.92	-0.94	1.56	-0.32	-0.20	-0.27
185	-6.02	-3.58	-1.53	-0.80	-0.28	1.21	-0.71	1.14	-0.92	-0.13	0.29
186	-5.70	-3.62	-1.01	-0.86	0.58	0.64	0.24	0.02	-0.13	0.29	-0.39
187	-5.14	-2.58	-0.86	-1.10	1.04	0.80	0.09	0.17	0.07	0.24	-0.50
188	-5.04	-2.43	-1.30	-1.22	1.23	0.41	0.65	-0.65	0.66	0.15	-0.29
189	-5.12	-2.32	-1.05	-0.79	1.38	0.07	0.49	-1.15	0.72	-0.30	0.18
190	-4.86	-2.40	-0.90	-0.69	1.01	-0.90	0.28	-0.90	0.46	-0.13	0.19
191	-5.09	-2.59	-0.52	-0.38	0.80	-1.80	0.45	0.16	-0.02	0.20	0.10
192	-4.97	-2.36	-1.34	-0.64	0.88	-2.61	0.71	0.74	-0.10	0.23	-0.21
193	-5.13	-1.81	-1.93	-0.18	1.14	-2.99	1.32	0.64	-0.26	-0.01	-0.33
194	-4.40	-1.59	-3.32	-0.01	1.39	-2.75	1.99	-0.33	-0.16	0.05	-0.07
195	-4.13	-1.83	-3.87	0.68	1.89	-2.02	2.06	-1.05	0.09	0.10	0.21
196	-3.47	-1.66	-4.59	1.04	2.07	-1.16	1.84	-1.27	0.73	0.05	0.16
197	-3.61	-1.20	-4.38	1.63	1.90	-0.21	1.15	-1.16	0.58	0.23	0.37
198	-2.94	-1.41	-3.92	1.33	2.20	0.26	0.85	-0.71	0.41	0.13	0.02
199	-2.79	-1.49	-3.46	0.85	2.48	0.65	0.42	0.28	-0.09	-0.08	-0.20
200	-3.12	-1.62	-3.54	0.21	2.67	0.32	-0.35	0.57	0.15	-0.33	0.14
201	-3.51	-1.90	-3.18	-0.50	2.35	-0.14	-1.38	0.96	-0.13	0.03	0.02
202	-3.99	-1.89	-3.43	-1.44	1.61	-0.79	-1.61	1.09	0.48	0.46	-0.24
203	-4.09	-1.59	-3.23	-1.92	1.00	-1.42	-0.50	0.63	0.16	0.53	-0.69
204	-4.12	-1.41	-2.84	-2.11	0.61	-1.69	0.53	0.72	-0.13	0.16	-0.67

Table C.1. cont'

205	-3.60	-1.34	-1.68	-2.11	0.35	-2.27	0.62	0.60	0.28	-0.18	0.06
206	-3.02	-1.36	-1.38	-2.41	1.05	-1.91	0.68	0.64	0.25	-0.36	0.22
207	-3.10	-1.55	-0.62	-2.27	1.99	-1.34	0.45	0.36	-0.38	-0.20	0.29
208	-2.78	-2.07	-0.16	-2.43	2.48	-0.75	0.76	0.13	-0.34	-0.21	-0.10
209	-2.67	-1.77	0.26	-2.45	2.43	0.12	1.54	-0.07	0.28	-0.42	0.23
210	-2.98	-1.41	0.25	-2.28	2.06	0.85	1.18	0.11	0.85	-0.15	0.14
211	-3.02	-1.39	0.78	-2.72	1.49	0.95	1.22	-0.01	0.42	0.37	-0.04
212	-2.95	-1.41	0.67	-2.89	1.19	0.42	0.85	-0.50	-0.77	0.28	0.46
213	-3.18	-1.66	0.60	-2.23	0.56	-0.47	0.31	-0.89	-0.95	-0.10	0.58
214	-2.74	-2.31	0.42	-2.09	-0.09	-1.35	-1.30	-0.88	0.10	0.23	-0.15
215	-2.54	-2.96	0.82	-2.42	-1.21	-1.80	-1.23	0.18	0.58	-0.05	-0.13
216	-2.54	-3.37	0.76	-2.58	-1.74	-1.72	-1.03	1.37	0.34	-0.42	0.27
217	-2.24	-3.86	0.94	-2.77	-1.51	-0.78	-0.62	1.52	-0.33	-0.46	0.12
218	-1.99	-4.25	0.69	-2.97	-0.81	0.16	0.00	0.47	-0.64	-0.35	0.08
219	-1.87	-4.08	0.67	-2.75	-0.07	0.82	0.31	-0.36	-0.75	-0.48	0.59
220	-1.85	-4.15	0.48	-2.57	0.46	0.90	0.51	-0.39	-0.48	0.34	0.16
221	-2.03	-3.58	0.54	-2.51	0.49	0.75	0.55	0.09	-0.14	0.58	-0.50
222	-2.40	-3.41	0.14	-2.83	0.67	0.42	0.78	-0.13	0.42	0.15	-0.39
223	-3.28	-3.35	0.24	-2.58	1.37	0.54	1.27	-0.54	0.17	-0.34	0.26
224	-3.62	-3.53	-0.02	-2.16	1.75	0.03	1.59	-0.81	-0.14	-0.43	0.29
225	-3.50	-3.32	0.09	-1.43	1.73	-0.14	1.45	-0.39	-0.40	0.00	0.36
226	-3.24	-2.93	-0.65	-0.68	1.10	-0.22	1.02	-0.15	-0.67	0.52	0.27
227	-2.92	-2.68	-1.29	-0.33	0.91	0.53	0.52	-0.00	-0.59	0.60	0.18
228	-2.70	-2.46	-2.10	0.14	0.53	1.10	-0.29	0.05	-0.47	0.10	-0.15
229	-2.52	-2.07	-2.55	0.71	0.16	1.35	-0.69	0.71	-0.61	0.10	0.10
230	-2.46	-1.56	-3.18	1.04	-0.16	1.51	-0.46	1.16	-0.89	0.14	0.21
231	-2.63	-1.28	-3.02	1.73	-0.41	1.54	-0.46	0.92	-0.56	-0.06	0.02
232	-2.63	-1.18	-3.40	2.51	-0.66	1.46	-0.91	1.11	0.13	-0.37	0.23
233	-2.78	-1.19	-3.25	2.87	-0.69	0.95	-1.27	1.16	0.09	-0.33	0.51
234	-2.85	-0.90	-3.38	2.91	-0.55	0.48	-1.74	0.98	0.03	0.26	0.21
235	-2.93	-0.70	-3.02	2.78	-0.38	-0.33	-2.10	0.80	-0.04	0.32	-0.33
236	-2.41	-0.80	-2.94	2.18	-0.26	-0.33	-2.00	0.58	-0.05	0.10	-0.23
237	-2.00	-0.94	-2.60	1.60	-0.13	-0.21	-1.71	0.49	-0.38	0.06	-0.04
238	-1.75	-0.87	-2.51	0.71	0.09	0.05	-0.71	0.46	-0.69	0.31	-0.16
239	-2.19	-0.95	-2.00	-0.07	0.37	0.46	0.56	0.57	-0.54	0.12	-0.27
240	-2.24	-0.91	-1.56	-0.49	0.98	1.04	1.51	0.62	0.02	-0.07	0.04

Table C.2. Values of BANPL for NUMB = 240

Row	Wave Number										
	1	2	3	4	5	6	7	8	9	10	11
1	-0.36	1.48	-0.86	3.74	0.25	1.55	0.60	0.10	0.51	-0.23	-0.01
2	-1.32	1.56	-0.68	3.77	0.14	1.57	0.63	-0.26	-0.06	-0.33	0.11
3	-1.27	1.56	-0.69	3.29	-0.01	1.60	0.85	-0.74	-0.27	-0.34	0.02
4	-1.88	1.62	-0.68	2.30	-0.20	1.23	1.22	-1.19	-0.33	-0.11	-0.03
5	-1.45	1.77	-0.71	1.72	0.48	1.81	1.27	-1.35	-0.16	-0.08	0.11
6	-1.67	1.12	-0.91	1.35	0.93	2.21	1.08	-0.88	-0.19	-0.04	0.09
7	-1.04	0.93	-1.17	1.13	1.33	3.19	0.82	-0.03	-0.86	0.51	-0.26
8	-1.01	1.12	-1.11	0.83	1.96	3.22	0.81	0.36	-0.42	0.26	-0.18
9	-0.53	1.40	-1.41	0.13	2.78	2.87	0.90	0.10	0.23	-0.18	-0.21
10	-0.76	1.94	-1.60	-0.58	3.82	2.52	0.43	0.09	0.16	-0.13	-0.63
11	-0.18	2.60	-1.89	-1.00	4.48	2.47	-0.29	0.45	0.21	0.09	-0.08
12	-0.48	2.97	-1.90	-1.53	4.30	2.10	-0.60	0.54	0.32	0.14	0.29
13	-0.29	3.19	-2.26	-2.08	3.87	1.17	-0.60	-0.03	-0.28	0.11	0.20
14	-0.24	3.24	-2.68	-2.61	3.18	0.67	-1.04	-0.40	-0.52	-0.21	0.32
15	0.53	2.61	-2.75	-2.67	2.09	-0.02	-1.75	-0.35	-0.49	-0.04	0.19
16	0.91	1.31	-2.07	-2.59	1.33	-0.53	-1.81	-0.14	0.10	-0.06	-0.02
17	1.70	0.42	-0.93	-2.47	0.94	-0.56	-1.26	0.15	-0.06	0.02	0.08
18	1.63	0.12	-0.44	-2.76	0.24	-0.49	-0.77	0.02	-0.49	0.28	0.40
19	1.74	0.24	-0.12	-2.84	0.24	-0.24	-0.19	-0.11	-0.28	0.54	0.09
20	1.22	0.39	0.51	-3.11	0.08	-0.45	0.64	-0.34	0.16	-0.20	-0.09
21	0.71	1.01	0.42	-2.90	-0.57	0.01	0.69	-0.0	0.36	-0.06	0.06
22	0.18	1.50	0.64	-2.93	-1.32	0.83	0.26	0.65	0.26	-0.05	0.25
23	-0.01	1.72	1.13	-2.78	-1.49	1.60	-0.24	0.98	-0.20	0.28	0.07
24	-1.01	1.82	1.32	-2.89	-1.44	1.55	-0.33	0.43	0.45	0.26	0.16
25	-1.19	1.84	1.59	-2.67	-0.76	1.23	-0.55	-0.43	0.65	0.30	0.04
26	-1.78	1.62	1.62	-2.20	-0.04	0.63	-0.79	-1.12	0.55	0.03	-0.16
27	-1.93	1.98	1.63	-1.80	0.50	0.13	-1.46	-1.10	-0.11	-0.21	-0.19
28	-2.23	2.61	2.03	-1.31	1.26	-0.32	-1.92	-0.42	-0.45	0.21	0.02
29	-2.38	3.10	1.77	-1.17	1.60	-0.80	-1.29	0.50	-0.02	0.35	0.01

Table C.2. cont'

30	-2.35	3.55	1.51	-0.86	2.12	-0.89	0.64	0.50	0.24	-0.20	0.15
31	-2.30	3.89	1.40	-0.22	2.22	-1.07	2.26	0.13	0.09	-0.16	0.07
32	-2.71	3.93	0.27	0.79	1.43	-0.56	2.73	-0.98	0.26	0.04	-0.13
33	-1.61	3.63	-0.84	1.14	0.67	0.63	1.08	-1.53	0.69	-0.13	-0.12
34	-2.16	2.95	-1.17	1.60	-0.45	1.43	-0.53	-0.28	-0.09	-0.10	0.15
35	-2.26	2.53	-1.66	1.36	-0.54	1.49	-1.10	0.28	-0.61	-0.03	-0.15
36	-2.91	2.52	-2.28	1.21	-0.59	1.21	-0.59	-0.12	-0.17	-0.23	0.17
37	-3.12	2.05	-2.35	1.31	-0.40	1.43	-0.75	-0.50	0.79	-0.61	0.20
38	-3.67	2.14	-2.00	0.38	-0.34	1.31	-0.75	-0.72	1.02	-0.19	0.09
39	-3.65	2.20	-1.84	0.92	0.48	0.93	0.06	-0.16	0.59	-0.14	-0.09
40	-4.02	2.55	-1.68	1.12	0.40	0.86	1.15	-0.60	0.32	0.18	0.07
41	-3.30	3.74	-1.57	0.49	-1.36	0.15	1.37	-1.03	1.20	0.06	0.02
42	-4.23	3.32	-1.86	1.25	-0.88	1.17	0.68	-0.95	0.58	-0.57	-0.0
43	-3.98	2.39	-2.07	2.30	-0.80	0.79	-0.94	-0.16	0.27	0.91	-0.39
44	-3.49	2.95	-1.96	0.38	-0.36	0.54	-0.74	-1.03	-0.29	0.44	-0.14
45	-2.73	2.73	-0.99	-0.38	-0.15	-0.23	-0.18	-0.52	-0.19	0.03	-0.10
46	-2.90	2.42	-0.53	-0.37	0.26	-0.68	0.04	0.40	-0.02	0.10	-0.20
47	-2.68	2.36	-0.15	-0.09	1.08	-1.09	0.46	0.73	0.14	0.40	-0.10
48	-3.18	2.82	0.15	0.11	1.36	-1.27	1.00	-0.02	-0.42	0.0	-0.12
49	-2.10	3.32	0.57	-0.0	1.21	-0.94	1.45	-1.05	-0.41	-0.55	-0.10
50	-1.41	3.21	0.30	0.08	1.07	-0.04	1.17	-1.33	0.20	-0.21	0.32
51	-0.33	3.50	0.30	-1.56	1.49	-0.54	1.19	-0.82	-0.01	0.35	0.11
52	-0.54	3.27	-1.11	-0.18	0.61	0.93	-0.24	-0.30	0.79	0.17	-0.12
53	-1.52	4.00	-3.48	0.01	0.90	1.59	-1.71	1.19	-1.07	-0.44	-0.69
54	-1.00	3.35	-2.51	-0.88	0.76	1.13	-0.92	0.61	-0.94	-0.15	-0.48
55	-1.35	3.10	-2.03	-1.97	1.12	0.85	-0.99	0.36	-0.83	0.27	0.27
56	-1.86	3.05	-2.29	-2.24	1.44	-0.28	-0.04	-0.09	-1.16	1.06	-0.18
57	-1.96	2.89	-2.00	-2.41	1.47	-0.96	0.70	-0.75	-0.35	0.62	-0.35
58	-2.49	2.57	-2.12	-2.37	1.31	-0.93	0.70	-0.38	0.56	-0.43	-0.16
59	-2.68	2.76	-2.29	-1.89	1.44	-0.73	1.00	0.04	0.75	-0.83	0.56
60	-2.72	2.70	-2.33	-1.69	1.41	-0.55	0.72	-0.10	0.12	-0.50	0.42
61	-1.93	2.34	-1.95	-1.25	1.00	-0.08	0.55	-0.58	-0.75	-0.18	0.08
62	-1.87	1.44	-1.64	-0.76	0.47	0.17	0.12	-0.93	-0.62	0.06	-0.32
63	-1.04	0.83	-0.88	0.10	0.09	0.29	-0.55	-1.23	0.21	0.05	-0.25
64	-1.29	0.55	-0.62	0.41	0.34	0.60	-0.35	-0.77	0.89	-0.11	-0.14

Table C.2. cont.

65	-0.61	0.88	-0.08	0.89	1.19	0.57	0.12	-0.20	0.86	-0.40	-0.05
66	-0.67	0.70	0.13	1.24	1.44	0.39	0.37	0.25	0.52	-0.46	0.19
67	-0.61	0.38	0.88	1.56	2.44	-0.14	0.84	-0.37	-0.48	0.24	0.46
68	-1.04	0.12	1.32	1.55	2.54	-0.35	0.38	-1.16	-0.46	0.84	-0.33
69	-0.61	-0.04	1.36	1.16	2.17	-0.49	-0.51	-1.33	-0.03	0.43	-0.21
70	-0.82	-0.07	1.33	0.64	1.81	-0.66	-1.26	-0.51	0.55	-0.23	0.25
71	-0.45	-0.17	1.54	-0.11	1.51	-1.22	-1.27	0.12	0.62	-0.48	0.18
72	-0.60	-0.12	1.80	-0.98	1.31	-1.82	-0.86	0.18	0.06	-0.53	-0.09
73	-0.44	-0.28	1.47	-1.57	1.34	-1.75	-0.05	0.03	-0.06	-0.42	-0.18
74	-0.85	-0.07	0.67	-1.64	1.40	-1.38	0.61	-0.13	0.27	-0.60	0.12
75	-0.70	0.62	0.31	-1.77	1.09	-1.08	0.90	-0.27	0.82	-0.69	0.19
76	-1.48	0.88	-0.28	-1.58	1.10	-0.73	1.16	-0.36	0.52	-0.44	-0.15
77	-1.53	1.15	-0.74	-0.99	0.65	-0.40	1.08	-0.34	-0.25	0.48	-0.28
78	-2.60	1.90	-1.26	-0.40	-0.06	-0.62	0.89	-0.45	-0.01	0.59	-0.02
79	-2.67	2.23	-1.45	-0.17	-0.33	0.39	0.51	0.20	0.03	0.19	-0.06
80	-3.21	2.84	-1.86	-0.06	-0.50	0.50	0.39	0.33	-0.0	0.24	0.11
81	-3.83	3.35	-2.21	0.61	-1.37	1.22	-0.04	0.74	0.25	-0.09	0.12
82	-3.80	3.75	-2.46	0.36	-0.82	1.60	-0.04	1.17	-0.01	-0.05	0.16
83	-3.09	3.96	-2.67	-0.02	-0.44	1.94	-0.18	1.00	-1.04	0.04	-0.03
84	-2.99	3.82	-2.90	-0.44	0.05	1.88	-0.11	0.52	-1.26	0.23	-0.13
85	-2.18	4.03	-2.35	-0.96	0.36	1.32	0.57	0.49	-0.63	0.24	-0.11
86	-2.22	3.77	-2.50	-1.22	0.46	1.17	0.22	0.22	-0.84	0.04	-0.14
87	-1.31	4.14	-2.04	-1.88	1.21	0.82	1.33	-0.02	-0.24	0.40	-0.17
88	-1.44	3.74	-2.16	-2.03	0.79	0.42	0.52	-0.06	-0.46	-0.16	-0.21
89	-1.07	3.66	-2.39	-2.02	0.26	0.55	-0.01	0.54	-0.73	-0.49	0.42
90	-1.51	3.29	-2.84	-1.57	-0.26	0.33	0.04	0.66	-0.77	-0.11	0.72
91	-0.14	2.64	-0.91	-2.26	-0.80	0.37	0.85	0.87	-0.41	-0.10	0.60
92	-0.68	1.84	-2.15	-1.41	-0.32	-0.11	0.62	-0.31	0.35	-0.31	0.06
93	-0.45	1.34	-1.51	-1.42	0.11	-0.09	0.15	-0.69	0.63	-0.21	-0.19
94	-0.52	1.03	-0.88	-1.65	0.84	0.16	-0.06	-0.55	0.87	0.13	-0.50
95	-0.47	0.38	-0.32	-2.16	0.75	0.39	-0.02	0.10	0.45	0.14	0.11
96	-0.49	0.16	0.20	-3.10	1.56	0.09	-0.16	0.39	0.30	0.29	0.56
97	-1.01	0.47	0.64	-4.01	2.42	-0.36	-0.47	0.69	-0.44	0.27	0.08
98	-1.30	-0.40	0.42	-3.96	2.38	-0.23	0.13	-0.09	-0.58	0.32	-0.31
99	-1.16	-0.24	0.28	-3.65	1.97	0.03	0.37	0.30	-0.41	0.15	-0.08

Table C.2. cont'

100	-1.29	0.39	0.53	-3.26	1.60	-0.19	0.53	0.17	-0.13	-0.24	0.14
101	-0.65	1.44	1.14	-2.43	0.84	-0.38	0.54	0.30	-0.05	-0.23	0.19
102	-2.39	1.05	-0.93	-1.79	0.70	0.88	0.13	-0.53	0.53	-0.31	0.13
103	-2.59	0.62	-1.50	-1.56	1.13	1.15	-0.59	-0.72	0.64	-0.23	0.0
104	-2.69	0.94	-2.69	-1.65	0.90	1.55	-1.11	-0.59	0.49	0.27	-0.18
105	-2.34	1.30	-3.17	-2.01	0.61	1.50	-1.51	-0.02	0.11	0.23	-0.36
106	-2.26	1.18	-3.26	-2.15	0.89	1.41	-1.50	0.86	0.13	0.28	0.06
107	-1.53	1.40	-3.28	-1.80	1.27	1.61	-1.47	0.83	-0.03	0.05	0.28
108	-1.75	1.48	-3.69	-0.66	1.61	1.42	-1.10	0.44	-0.16	-0.24	0.28
109	-1.32	1.24	-4.73	0.0	1.87	1.07	-0.55	0.12	0.14	-0.03	0.33
110	-0.80	1.47	-5.27	0.53	1.98	0.17	-0.25	0.10	0.68	-0.05	0.01
111	0.40	1.57	-5.35	0.39	2.00	-0.55	0.04	0.18	0.83	-0.60	-0.02
112	0.55	1.71	-5.16	0.04	1.71	-1.06	0.21	-0.45	0.56	-0.54	0.06
113	1.40	2.84	-3.34	-0.71	1.99	-0.65	0.52	-0.28	0.25	0.14	-0.17
114	0.48	2.74	-2.90	-0.74	2.00	-0.65	0.25	-0.62	0.20	0.45	0.06
115	0.19	1.64	-2.70	-0.77	2.22	-0.74	0.61	-0.67	0.38	0.18	-0.24
116	-0.37	1.47	-3.28	-0.15	2.05	-1.13	0.74	-0.77	0.63	-0.64	-0.01
117	-0.34	1.11	-4.02	-0.28	1.78	-0.85	0.57	-0.62	0.59	-0.31	0.04
118	-0.52	0.83	-4.09	0.17	1.32	-0.54	-0.18	-0.0	-0.34	0.40	0.22
119	0.22	0.97	-4.07	0.44	1.04	-0.57	0.0	-0.05	-0.85	0.91	-0.07
120	0.31	0.60	-4.40	-0.03	0.51	-0.22	0.47	0.18	-1.17	0.78	-0.56
121	0.15	1.18	-4.52	-0.88	0.01	0.87	0.05	0.65	0.17	-0.14	0.26
122	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
123	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
124	-0.17	1.49	-4.72	-1.97	0.05	1.31	-0.87	0.51	-0.28	-0.67	-0.17
125	-0.39	1.67	-4.27	-2.42	0.74	1.05	-0.63	0.11	-0.09	-0.37	0.14
126	-0.23	2.30	-3.44	-2.88	1.23	0.53	-0.61	-0.16	0.02	-0.15	0.27
127	-0.37	2.71	-2.44	-3.04	1.97	0.29	-0.18	-0.19	0.16	-0.05	0.04
128	-0.55	3.04	-1.43	-3.15	2.70	0.12	0.32	-0.14	0.25	0.09	-0.21
129	-0.61	3.25	-0.84	-2.73	3.04	0.71	1.01	-0.28	0.50	-0.25	0.03
130	-1.09	3.25	-0.39	-2.11	3.10	0.68	1.25	-0.35	0.52	-0.72	0.17
131	-0.67	3.48	-0.46	-1.61	3.05	0.63	1.25	-0.67	0.04	-0.36	-0.21
132	-0.52	3.45	-0.17	-1.72	3.01	-0.14	0.84	-0.59	-0.54	-0.14	-0.20
133	-0.01	3.45	-0.39	-1.96	2.84	-0.49	-0.06	-0.46	-0.76	-0.05	0.61
134	0.07	3.55	-0.37	-2.27	2.70	-0.85	-0.20	-0.69	-0.69	0.12	0.20

Table C.2. cont'

135	-0.05	3.50	-0.61	-2.21	2.51	-1.06	0.22	-0.58	-0.14	-0.02	-0.07
136	-0.20	3.47	-0.75	-2.21	2.29	-1.28	0.69	-0.40	0.46	-0.18	-0.34
137	-0.22	3.30	-1.58	-1.61	2.07	-0.76	0.93	0.14	0.67	-0.18	-0.26
138	-0.38	3.23	-2.75	-1.64	1.52	-0.53	0.98	0.30	-0.14	-0.30	-0.36
139	-0.23	2.61	-3.55	-1.33	1.01	0.13	0.71	0.45	-0.71	0.20	-0.10
140	-0.77	2.32	-3.73	-1.22	0.82	0.70	0.43	0.05	-0.56	0.48	0.11
141	-0.77	2.32	-3.73	-1.22	0.82	0.70	0.43	0.05	-0.56	0.48	0.11
142	-1.37	1.21	-3.65	-0.42	1.30	2.16	0.24	-0.43	0.70	-0.17	-0.25
143	-1.02	1.38	-3.14	0.06	1.29	2.16	-0.31	-0.64	0.44	-0.79	-0.14
144	-1.41	1.73	-2.95	0.15	1.31	1.91	-0.83	-0.41	-0.44	-0.25	-0.19
145	-0.93	1.87	-3.18	0.23	1.34	1.41	-0.93	-0.21	-0.61	0.24	-0.37
146	-0.85	1.75	-3.72	-0.10	1.29	0.69	-0.22	-0.25	-0.20	-0.22	-0.12
147	-0.85	1.64	-4.17	-0.45	1.25	0.08	0.35	-0.33	0.28	-0.66	0.11
148	-1.16	1.83	-4.35	-0.54	1.22	-0.50	0.54	-0.33	-0.16	-0.15	0.09
149	-0.71	1.87	-4.13	0.03	1.22	-0.61	-0.21	-0.42	-0.55	0.49	-0.34
150	-0.33	1.80	-3.93	0.42	0.98	-1.04	-0.76	-1.17	-0.12	0.20	0.46
151	0.40	1.49	-4.05	0.87	0.57	-1.19	-0.83	-0.68	0.69	0.04	0.18
152	0.20	1.11	-4.36	1.15	0.63	-0.47	-0.74	0.11	0.44	0.30	-0.66
153	0.51	0.95	-4.12	1.38	0.46	0.42	-0.63	0.21	-0.26	-0.34	-0.52
154	-0.35	0.93	-4.05	1.49	0.26	1.23	-0.52	0.17	-0.47	-0.03	-0.15
155	-1.03	1.27	-4.19	1.43	0.26	0.96	0.18	-0.13	-0.57	0.01	0.01
156	-0.68	0.28	-3.56	1.02	0.29	0.77	0.60	-0.17	-0.52	-0.10	0.05
157	-0.15	-0.02	-2.97	1.05	0.55	0.20	0.99	-0.26	-0.25	0.30	-0.20
158	-0.03	-0.59	-2.16	0.76	0.72	-0.0	1.53	0.11	-0.10	0.24	-0.30
159	0.56	-0.76	-2.07	0.44	0.96	0.22	1.22	-0.24	-0.02	-0.03	0.08
160	0.63	-0.87	-1.98	0.05	0.86	-0.06	0.15	-0.65	0.12	-0.10	0.33
161	0.77	-1.06	-1.83	0.09	1.11	-0.05	-0.60	-0.56	0.55	0.26	-0.17
162	0.09	-0.67	-2.07	-0.02	1.22	0.16	-1.01	-0.11	0.22	0.20	-0.24
163	-0.08	-0.46	-2.25	-0.20	1.75	0.12	-1.03	0.34	-0.06	-0.49	0.28
164	-0.86	-0.01	-2.84	-0.41	2.08	0.46	-1.18	0.41	-0.30	-0.37	0.26
165	-0.56	0.06	-3.18	-0.70	2.72	0.88	-1.42	0.22	-0.44	0.20	-0.0
166	-1.19	0.02	-2.82	-0.83	3.27	1.30	-1.14	-0.33	-0.16	0.12	-0.06
167	-0.67	0.10	-2.59	-0.58	3.22	1.61	-0.76	-0.30	0.11	-0.17	-0.12
168	-0.81	0.30	-1.50	-0.56	2.44	1.78	-0.17	-0.33	-0.22	-0.09	-0.03
169	-1.07	0.78	-1.62	-0.72	2.23	1.73	-0.33	-0.37	-0.35	-0.02	-0.04

Table C.2. cont'

170	-2.16	1.02	-1.23	-0.57	1.73	1.08	-0.14	-0.29	0.01	-0.21	-0.06
171	-2.30	1.50	-1.34	-0.56	0.85	0.54	0.33	-0.28	0.25	-0.02	-0.05
172	-2.93	1.66	-1.26	-0.64	0.24	-0.23	0.81	-0.46	0.28	-0.25	-0.28
173	-3.04	1.85	-1.54	-0.10	0.10	0.01	0.75	-0.79	0.12	-0.16	-0.19
174	-3.67	1.84	-2.08	0.26	-0.05	-0.23	-0.32	-0.81	0.06	0.33	0.13
175	-3.08	1.52	-2.17	0.53	0.40	-0.21	-1.16	-0.74	-0.34	0.55	-0.29
176	-3.50	1.23	-2.27	0.68	0.91	-0.20	-1.39	-0.33	-0.48	0.36	-0.0
177	-2.73	1.11	-1.90	0.71	1.70	-0.72	-0.91	0.33	0.09	-0.14	0.39
178	-2.45	1.15	-1.07	0.62	2.49	-1.48	-0.28	0.85	0.16	-0.14	0.29
179	-2.07	1.17	-0.24	0.80	2.89	-1.68	0.18	0.99	0.02	-0.01	-0.16
180	-2.17	1.47	0.57	0.30	3.53	-1.83	0.76	0.62	0.50	0.24	-0.09
181	-1.93	2.00	0.90	0.12	3.45	-1.58	1.20	-0.52	0.36	-0.16	-0.09
182	-2.18	2.84	0.59	-0.36	2.40	-1.58	1.00	-1.53	0.14	-0.14	0.03
183	-1.69	3.12	0.18	-0.66	0.92	-1.28	0.59	-0.92	0.48	0.51	0.13
184	-1.85	2.49	-0.30	-0.71	-0.42	-0.89	0.26	0.01	0.90	0.19	-0.23
185	-1.19	2.06	-0.85	-1.14	-0.90	-0.32	-0.27	0.52	0.22	-0.15	-0.35
186	-0.34	1.54	-1.38	-1.54	-0.43	-0.02	-0.50	1.20	-1.00	0.42	-0.34
187	-0.78	1.61	-1.44	-1.83	-0.38	0.64	-0.91	1.09	-0.85	-0.04	0.30
188	-1.12	1.47	-1.36	-1.60	-0.36	1.02	-0.67	1.10	-0.53	0.45	-0.44
189	-0.24	1.62	-1.34	-0.78	-0.11	1.81	-0.22	0.50	0.14	0.38	-0.32
190	-0.55	1.27	-1.41	-0.41	-0.20	2.38	-0.53	-0.60	0.37	0.03	-0.01
191	0.36	1.16	-1.15	-0.18	-1.00	2.17	-1.11	-0.78	0.23	-0.11	0.01
192	-0.33	0.73	-1.32	-0.28	-1.50	1.72	-1.35	-0.18	0.06	0.06	-0.10
193	-0.06	0.61	-1.79	-0.20	-1.88	0.86	-1.04	0.84	-0.08	0.24	-0.12
194	-0.99	0.62	-2.20	0.11	-1.82	0.17	-0.44	1.32	-0.38	0.23	-0.46
195	-1.00	1.33	-2.30	0.91	-2.03	-0.63	0.19	0.98	-0.78	0.31	-0.30
196	-1.93	1.70	-2.15	1.46	-1.86	-1.25	0.96	0.10	-0.10	0.25	0.06
197	-1.85	1.64	-1.76	2.18	-1.39	-0.75	1.39	-0.70	0.25	-0.08	0.18
198	-2.35	1.31	-1.54	2.83	-0.76	0.06	1.52	-1.38	0.47	0.27	0.46
199	-1.65	1.28	-1.40	3.55	-0.26	0.85	1.71	-1.17	0.39	0.39	0.14
200	-1.43	0.88	-1.14	3.94	0.42	1.79	1.98	-0.86	0.03	-0.06	-0.01
201	-0.08	1.11	-0.98	4.11	1.08	2.16	1.29	-0.73	-0.14	-0.51	0.12
202	-0.24	0.87	-0.83	3.83	1.15	2.31	-0.40	-0.07	-0.26	-0.40	0.26
203	0.71	1.04	-1.13	3.77	0.91	1.87	-1.42	-0.04	0.35	0.03	0.16
204	-0.03	0.51	-1.75	2.86	0.48	1.60	-0.76	0.13	0.22	0.58	-0.62

Table C.2. cont'

205	0.13	0.40	-1.58	2.64	-0.40	0.60	-0.34	0.31	-0.11	0.34	-0.66
206	-1.17	0.23	-1.96	2.23	-1.32	-0.50	0.02	0.54	0.46	-0.09	-0.46
207	-1.54	0.14	-2.59	2.24	-1.52	-1.28	-0.36	0.64	0.41	0.07	0.17
208	-3.09	-0.05	-3.17	2.08	-0.55	-1.53	-0.70	0.76	-0.08	0.23	-0.08
209	-2.75	0.22	-3.67	2.13	0.21	-1.46	-0.37	0.35	-0.67	-0.04	-0.16
210	-3.32	0.62	-3.94	1.81	0.94	-0.88	0.20	0.26	0.10	-0.27	0.17
211	-2.61	1.31	-3.37	2.01	1.13	0.12	0.48	0.82	1.12	-0.09	-0.10
212	-2.59	1.28	-2.68	1.31	1.50	1.10	1.25	0.49	0.55	0.45	-0.33
213	-1.71	1.64	-1.88	0.53	1.76	1.57	1.56	-0.26	-0.29	0.40	0.28
214	-1.49	1.57	-1.08	-0.20	1.79	1.46	1.15	-0.99	-0.68	-0.06	0.31
215	0.08	1.48	-0.42	-0.55	1.13	0.55	0.04	-1.69	0.06	0.36	-0.25
216	0.15	1.09	0.09	-1.03	-0.15	-0.46	-0.37	-1.04	0.78	0.36	-0.20
217	1.15	1.58	0.62	-1.19	-1.49	-0.94	-0.64	0.51	0.82	-0.19	-0.09
218	0.33	1.76	0.42	-1.46	-2.30	-1.03	-0.67	1.13	0.33	-0.16	-0.37
219	0.52	2.16	0.11	-1.50	-2.76	-0.56	-0.61	0.73	0.09	-0.60	0.03
220	-0.39	2.19	0.13	-1.48	-2.80	-0.14	-0.32	0.14	-0.31	-0.63	0.74
221	-0.13	2.07	0.58	-1.27	-2.67	-0.02	-0.13	0.02	-0.55	0.11	0.45
222	-0.88	1.92	0.86	-1.41	-2.99	-0.28	-0.03	0.40	-0.23	0.52	-0.40
223	-0.39	2.00	0.51	-1.82	-2.80	-0.26	-0.02	0.40	0.39	0.07	-0.47
224	-1.00	1.69	0.34	-2.38	-2.13	-0.36	0.74	-0.19	0.45	-0.47	-0.11
225	-0.65	1.79	0.18	-2.49	-1.57	-0.75	1.30	-0.36	0.39	-0.73	-0.03
226	-1.62	2.20	0.61	-2.43	-0.96	-1.52	1.66	-0.36	0.26	-0.30	0.05
227	-1.53	2.81	0.61	-2.51	-1.01	-1.63	1.79	-0.36	0.06	0.16	0.23
228	-2.17	3.25	0.75	-2.48	-1.10	-1.44	1.55	-0.91	-0.10	0.23	0.13
229	-1.55	3.75	0.81	-2.19	-1.21	-0.86	1.01	-1.03	0.01	-0.12	-0.06
230	-2.49	3.69	0.92	-1.98	-1.15	-0.50	0.82	-0.64	-0.28	0.10	0.21
231	-2.05	4.20	0.91	-2.02	-1.16	0.06	0.94	-0.20	-0.69	0.14	0.13
232	-3.04	3.99	1.04	-1.94	-1.27	0.34	1.55	-0.17	-0.54	-0.02	-0.17
233	-2.71	4.12	1.39	-1.72	-1.48	0.58	1.29	0.13	-0.35	-0.22	0.02
234	-3.83	3.86	1.47	-1.66	-1.15	0.57	0.80	0.41	-0.15	-0.38	0.38
235	-3.33	3.89	1.22	-1.23	-0.66	0.04	0.45	0.49	-0.18	0.02	0.18
236	-4.04	3.51	0.69	-1.10	-0.38	-0.90	-0.34	0.44	-0.12	0.18	-0.21
237	-3.32	3.27	0.40	-0.46	-0.01	-1.55	-1.34	0.24	-0.09	0.03	-0.15
238	-3.84	2.69	0.16	-0.44	0.32	-2.14	-1.62	0.10	-0.36	0.11	-0.25
239	-2.90	2.55	-0.15	0.02	0.21	-2.79	-1.79	0.07	-0.73	0.30	-0.33
240	-3.66	2.39	-0.49	0.21	0.67	-3.10	-0.94	0.03	-0.97	0.17	-0.46

APPENDIX D

(Northern Data Set)

Figure D.1. to D.11.

Amplitude versus Time for space-waves of wave number 1 to 11, respectively. Time is indicated as days after Dec. 1, 1976.

Table D.1.

Values of AAMPL for NUMB = 240.

Table D.2.

Values of BAMPL for NUMB = 240.

Figure D.1.

Wave Number 1

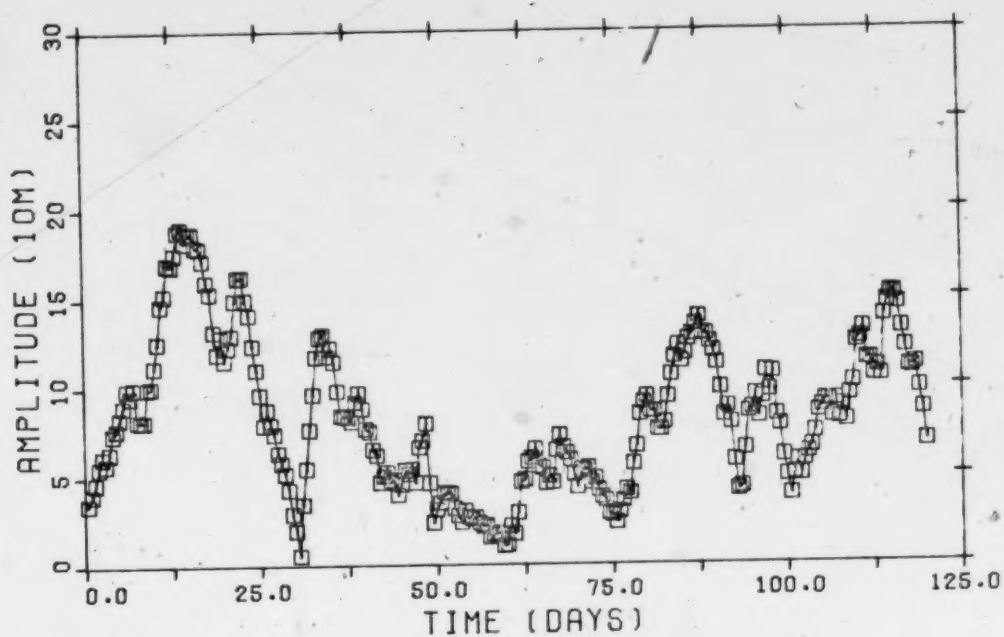


Figure D.2.

Wave Number 2

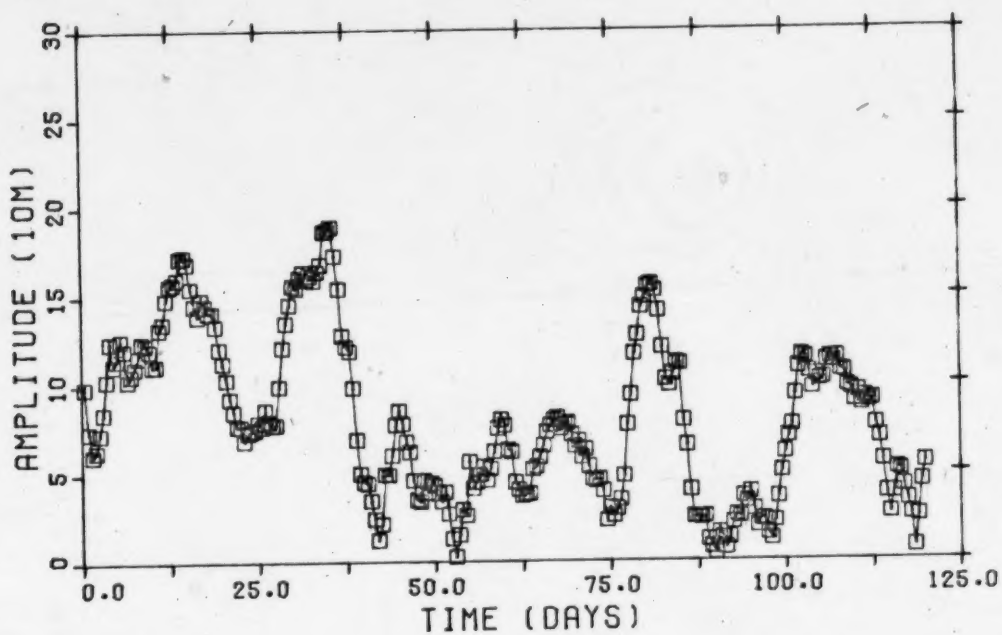


Figure D.3.

Wave Number 3

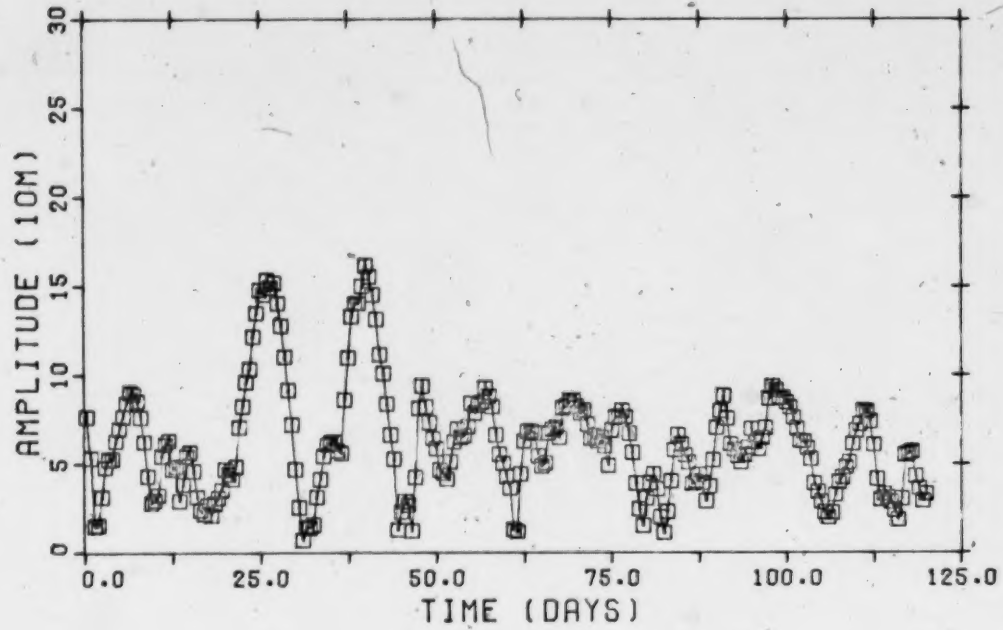


Figure D.4.

Wave Number 4

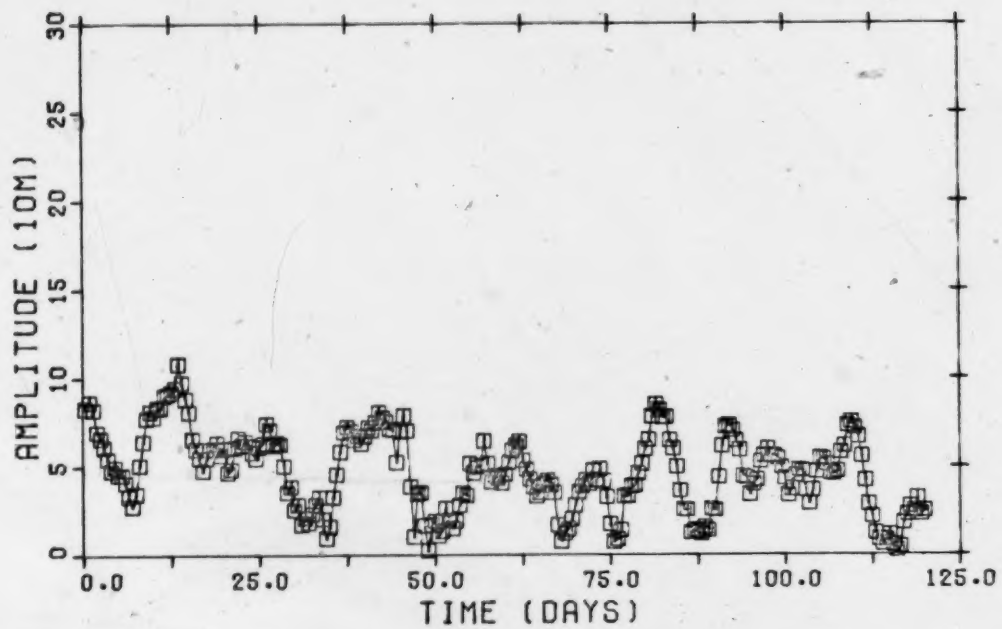


Figure D.5.

Wave Number 5

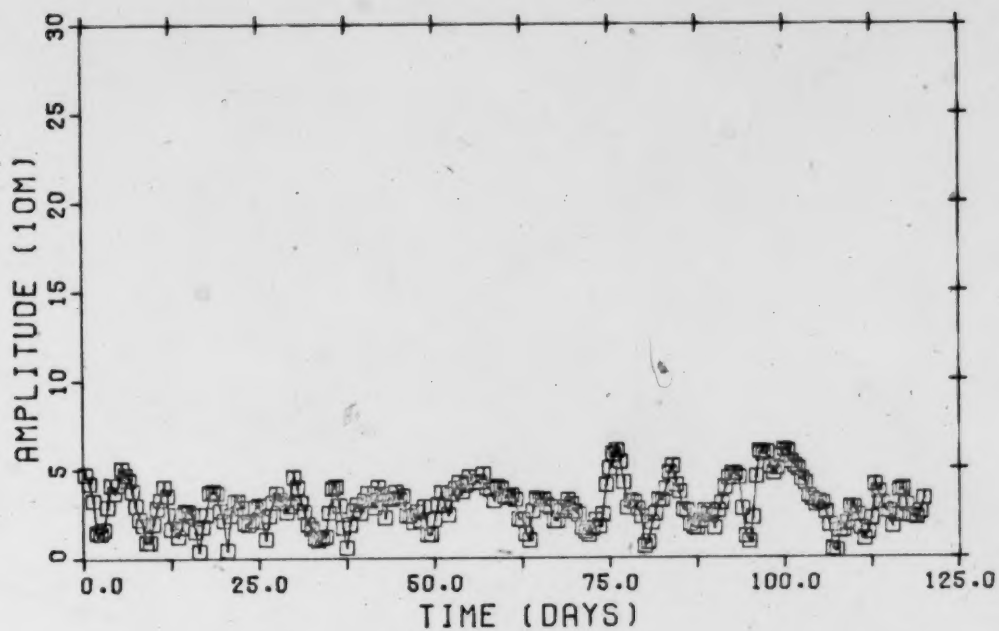


Figure D.6.

Wave Number 6

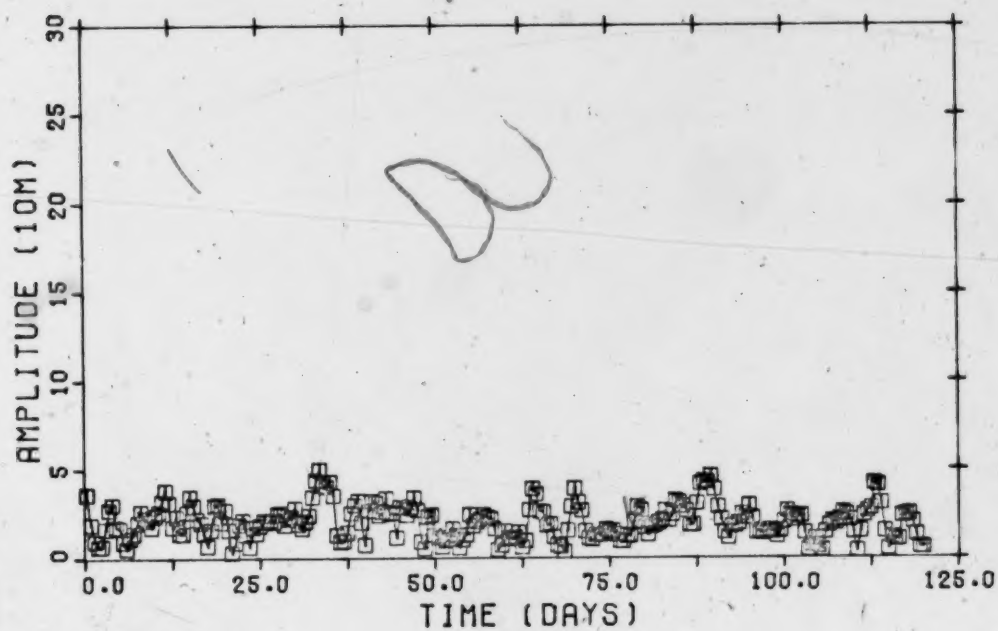


Figure D.7.

Wave Number 7

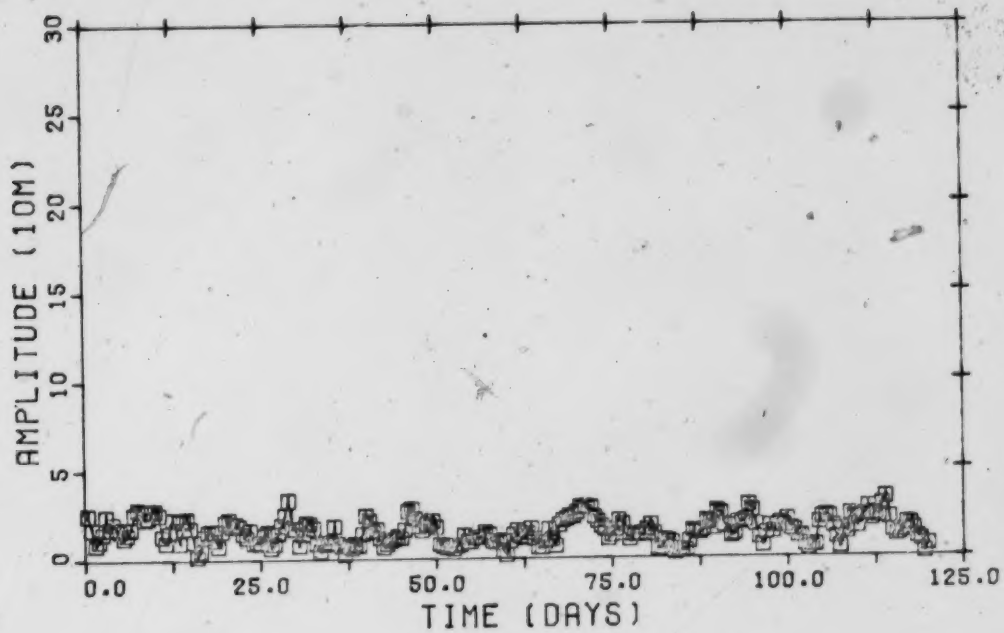


Figure D.8.

Wave Number 8

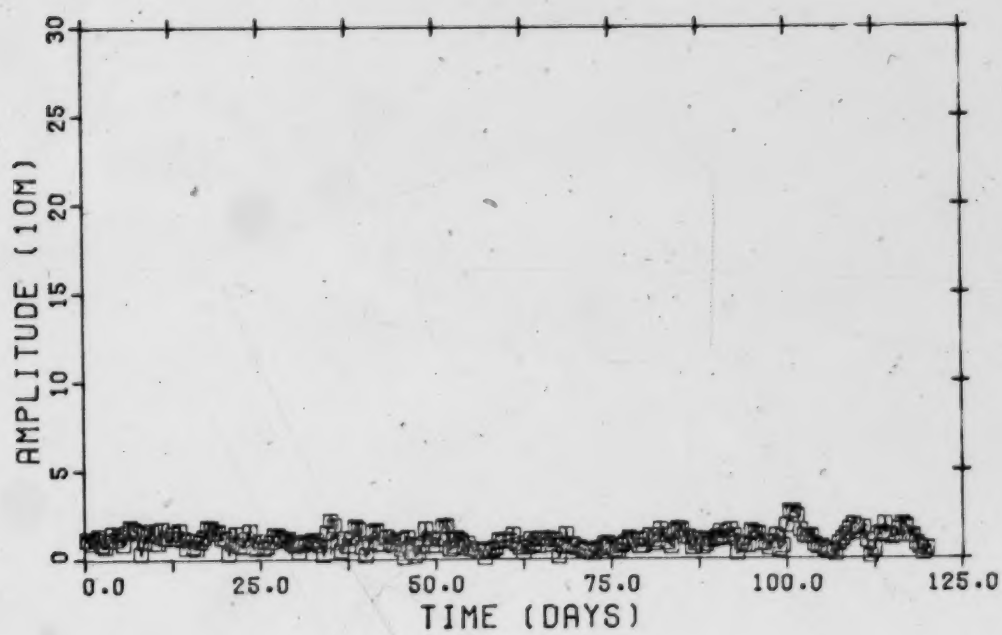


Figure D.9.

Wave Number 9

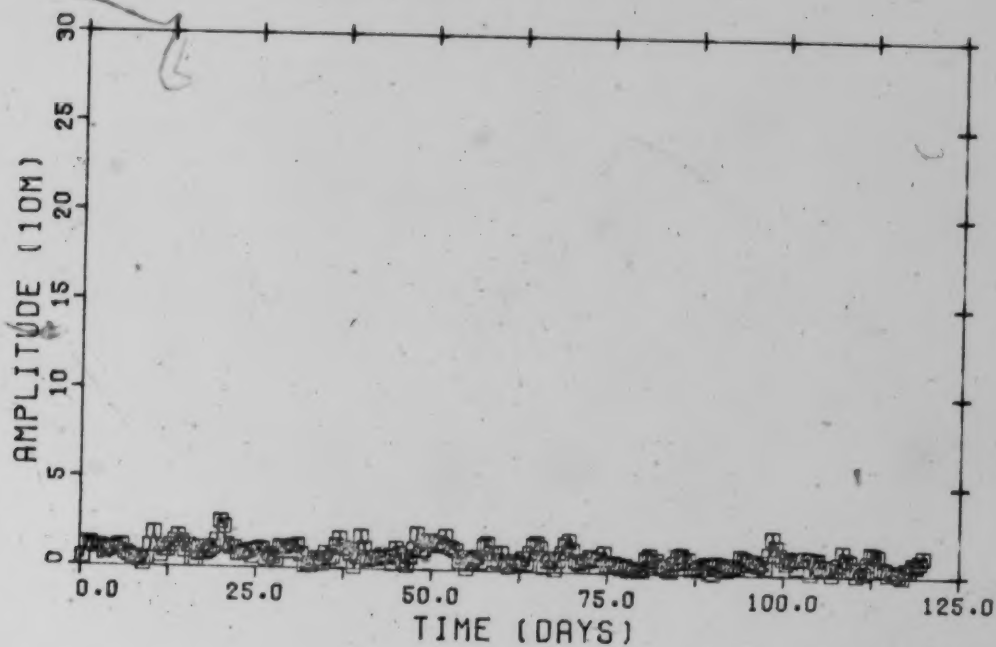


Figure D.10.

Wave Number 10

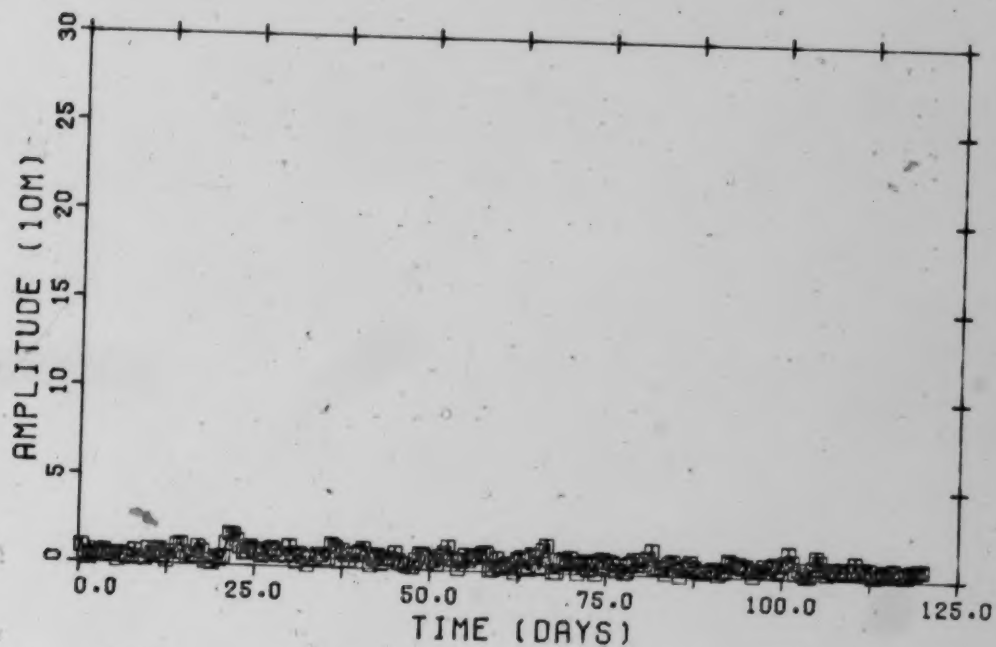


Figure D.11.

Wave Number 11

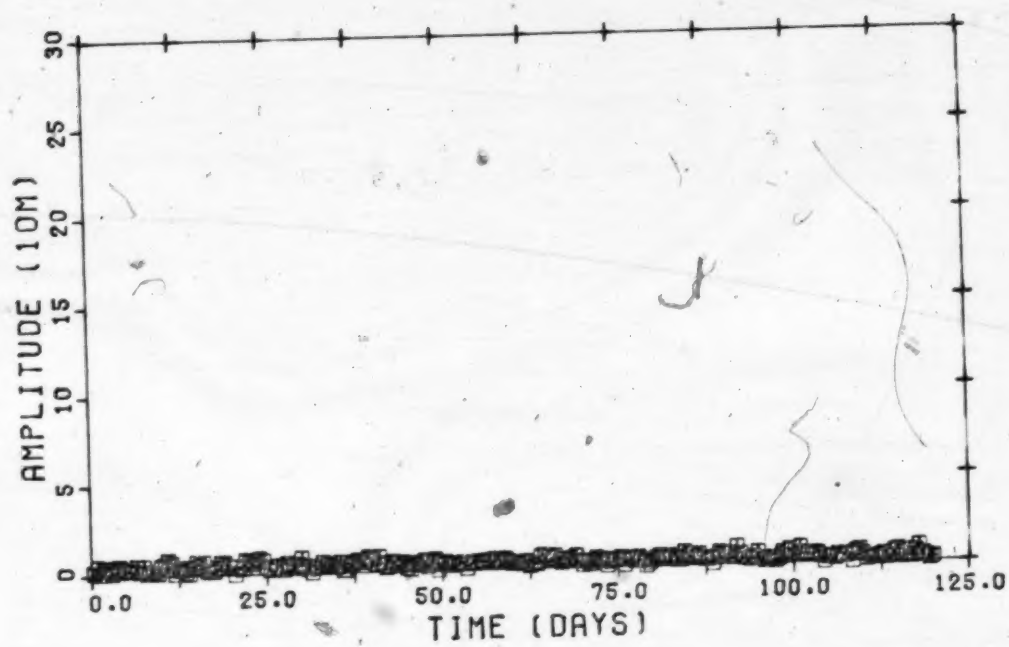


Table D.1. Values of AAMPL for NUMB = 240

Row	Wave Number										
	1	2	3	4	5	6	7	8	9	10	11
1	1.48	-3.37	-1.89	3.66	-1.24	-1.68	-1.08	0.47	-0.14	0.41	0.01
2	1.74	-3.13	-0.88	3.89	-1.32	-0.91	-0.45	0.03	-0.48	0.05	-0.16
3	1.96	-2.86	-0.54	3.81	-1.30	0.13	0.26	-0.54	-0.62	0.02	-0.05
4	2.58	-2.89	-0.58	3.16	-0.63	0.31	0.53	-0.47	-0.10	0.19	-0.16
5	2.96	-3.16	-0.59	2.87	-0.63	0.31	0.75	-0.11	0.29	-0.09	-0.25
6	2.85	-3.46	-1.16	2.49	-0.81	0.80	0.96	0.32	0.52	-0.22	-0.04
7	3.09	-3.87	-1.55	2.43	-0.79	1.32	-0.21	0.54	0.21	-0.11	0.15
8	3.36	-4.65	-1.39	2.15	0.06	1.01	-0.99	0.73	-0.20	0.22	-0.06
9	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
10	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
11	3.69	-5.59	-1.61	1.55	2.51	-0.21	-0.25	0.06	0.12	-0.01	0.01
12	3.86	-5.60	-1.83	1.46	2.28	-0.28	-0.10	0.51	-0.32	-0.24	0.15
13	3.56	-4.60	-2.17	1.30	1.91	-0.35	-0.06	0.80	-0.31	0.04	0.11
14	3.61	-4.18	-2.19	1.23	1.32	-0.39	0.30	0.84	-0.15	0.14	0.01
15	2.06	-3.57	-2.12	1.59	0.82	-0.15	1.07	0.75	0.20	-0.09	-0.25
16	1.02	-3.06	-2.00	2.51	0.32	0.22	1.37	0.05	-0.07	-0.25	0.04
17	-0.25	-2.69	-1.95	3.22	0.03	0.32	0.71	-0.36	0.08	0.03	-0.10
18	-0.05	-1.66	-1.56	3.78	-0.21	0.67	-0.38	-0.26	0.06	-0.02	-0.04
19	-0.38	-1.38	-1.27	3.86	-0.02	0.88	-1.38	0.19	-0.07	0.05	-0.01
20	-1.34	-1.91	-1.48	3.50	0.51	0.66	-1.07	0.45	-0.54	0.39	-0.05
21	-0.91	-0.77	-1.28	3.82	0.95	0.17	-0.41	-0.36	-0.48	-0.04	-0.03
22	-1.95	-1.08	-1.85	3.82	1.39	-0.52	0.0	-0.85	0.17	-0.28	0.33
23	-2.06	-1.36	-1.00	4.20	1.96	-0.88	0.32	-0.57	0.25	-0.21	0.17
24	-2.94	-2.40	-0.08	4.22	1.70	-1.12	0.72	-0.60	0.04	-0.18	-0.03
25	-3.93	-3.09	0.58	4.52	0.66	-0.64	1.14	-0.75	-0.23	-0.08	0.14
26	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
27	-5.72	-3.25	-0.09	5.25	0.14	-0.13	-0.10	-0.23	-0.10	-0.14	-0.09
28	-6.16	-2.92	-0.26	4.74	-0.02	0.24	-1.05	0.45	-0.55	0.36	0.03
29	-5.86	-2.46	-0.42	4.36	-0.50	-0.19	-0.65	0.25	-0.68	0.45	-0.16

Table D.1. cont'

30	-5.86	-2.39	-0.21	3.99	-0.67	-1.34	0.47	0.40	-0.07	-0.11	-0.03
31	-6.39	-1.99	0.24	3.28	-0.40	-1.47	0.51	0.35	0.22	-0.13	-0.04
32	-6.28	-2.60	0.53	3.00	-0.12	-1.10	-0.08	0.15	0.04	-0.02	-0.17
33	-6.53	-2.67	0.43	2.74	-0.17	-0.85	0.20	-0.34	-0.17	-0.23	0.04
34	-6.69	-2.64	0.91	2.37	-0.84	-0.50	0.47	-0.64	-0.48	-0.47	0.04
35	-6.67	-1.66	1.34	2.59	-1.19	0.10	0.16	-0.61	-0.35	-0.37	0.09
36	-6.66	-1.47	1.06	2.84	-1.84	0.65	-0.41	-0.15	-0.37	-0.07	0.10
37	-5.99	-1.24	1.26	2.72	-1.84	0.81	-0.53	0.36	-0.29	-0.02	-0.29
38	-5.42	-1.56	0.96	3.01	-1.79	0.50	-0.28	0.70	-0.43	-0.01	-0.33
39	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
40	-4.90	-1.85	0.44	3.00	-1.07	0.20	0.84	0.50	-1.13	0.06	0.01
41	-5.17	-1.49	-0.24	2.29	0.21	0.06	1.13	-0.15	-0.50	0.02	0.01
42	-5.43	-1.35	-1.04	2.07	0.88	0.02	0.92	-0.21	0.16	-0.34	-0.21
43	-6.75	-0.58	-1.76	2.50	0.84	-0.21	0.91	0.02	0.53	-0.83	-0.01
44	-7.38	-0.44	-2.92	2.66	0.75	0.24	0.81	0.16	0.31	-0.82	0.29
45	-7.53	0.20	-3.36	2.70	0.70	0.62	0.51	0.13	-0.14	-0.30	0.35
46	-7.15	1.43	-4.25	2.84	0.53	0.63	0.58	-0.08	-0.33	0.18	0.10
47	-6.97	2.11	-4.77	2.74	0.95	-0.11	0.82	-0.19	-0.17	-0.05	-0.08
48	-6.15	2.90	-5.87	2.77	1.06	-0.74	0.45	-0.12	0.20	-0.21	-0.41
49	-5.51	3.50	-6.69	2.73	1.17	-0.56	0.37	-0.05	0.04	-0.43	-0.32
50	-4.72	3.90	-7.37	3.06	1.23	-0.65	0.42	-0.18	0.03	-0.38	-0.06
51	-3.67	3.79	-7.27	3.10	0.97	-1.05	0.70	-0.17	-0.45	-0.32	-0.02
52	-3.91	4.14	-7.67	3.50	0.49	-1.04	0.76	0.19	-0.22	-0.03	0.16
53	-3.12	3.48	-7.33	3.38	0.68	-0.99	0.15	0.0	-0.23	0.33	-0.20
54	-3.11	2.53	-7.32	3.03	0.60	-1.00	-0.36	0.03	-0.16	0.21	-0.05
55	-3.03	1.11	-6.64	3.15	0.38	-1.24	-0.45	0.33	0.07	-0.31	0.01
56	-2.84	-0.54	-5.75	3.14	0.24	-1.26	0.02	0.57	0.18	-0.43	0.23
57	-2.57	-2.21	-4.52	2.50	0.56	-0.67	0.97	0.48	0.10	-0.02	0.15
58	-2.10	-3.68	-3.52	1.78	0.63	-0.72	1.40	0.49	-0.21	0.06	0.13
59	-1.35	-4.78	-2.44	1.80	0.91	-0.65	0.82	0.26	-0.37	-0.25	0.19
60	-0.96	-6.29	-1.40	1.09	0.85	-0.68	0.86	0.40	-0.36	-0.45	0.17
61	0.02	-7.02	-1.07	0.79	0.14	-0.04	0.05	-0.04	-0.28	-0.26	0.17
62	0.45	-7.86	0.32	0.45	-0.36	0.82	0.02	-0.0	-0.47	-0.01	-0.09
63	0.42	-8.18	0.71	0.95	-1.00	1.01	-0.29	0.24	-0.37	0.27	-0.02
64	0.73	-7.91	0.45	0.90	-0.90	1.17	-0.65	0.45	-0.03	0.13	0.18

Table D.1. cont'

65	-0.22	-7.56	-0.46	1.03	-0.85	1.69	-0.81	0.27	0.07	-0.06	0.16
66	-0.99	-6.82	-0.79	1.30	-0.47	1.93	-0.43	-0.33	-0.07	0.23	0.30
67	-1.98	-5.93	-0.83	1.26	-0.05	1.84	-0.17	-0.26	0.26	-0.06	0.19
68	-2.73	-5.18	-0.84	0.65	0.39	1.33	0.47	-0.13	0.12	-0.33	0.20
69	-3.43	-5.38	0.26	0.37	0.62	1.08	0.43	-0.67	0.11	0.17	0.15
70	-4.10	-5.85	0.20	0.52	1.21	0.73	0.45	-1.01	0.31	0.24	0.16
71	-4.38	-6.31	0.20	0.79	1.70	-0.05	0.78	-0.89	0.27	0.19	0.09
72	-4.29	-5.95	-0.93	1.04	1.03	-0.13	0.14	-0.26	0.29	-0.14	-0.06
73	-4.10	-5.12	-2.13	1.74	0.16	-0.08	0.26	0.14	0.05	-0.58	-0.02
74	-4.17	-3.66	-3.97	2.53	-0.45	0.36	0.03	0.56	-0.75	-0.28	0.18
75	-4.14	-2.77	-5.23	2.89	-0.24	0.24	-0.06	0.05	-0.57	0.17	0.16
76	-4.04	-1.52	-6.40	3.11	-0.04	-0.36	-0.0	-0.48	-0.38	0.33	-0.17
77	-4.52	-0.61	-6.85	2.99	0.99	-1.28	0.36	-0.89	0.22	0.18	-0.10
73	-4.72	-0.08	-6.97	2.79	1.49	-1.59	-0.04	-0.80	0.01	0.33	-0.36
73	-4.31	0.51	-7.50	2.59	1.05	-0.87	-0.38	-0.27	-0.19	0.17	-0.30
80	-3.78	1.60	-8.00	3.00	0.66	0.28	-0.73	-0.10	-0.68	-0.11	0.01
81	-3.66	2.10	-7.44	3.11	1.00	1.33	-0.44	0.46	-0.52	-0.07	0.20
82	-3.21	1.72	-6.53	2.78	1.10	1.57	-0.61	0.77	-0.25	0.19	0.26
83	-3.08	1.16	-5.71	2.57	0.81	1.42	-0.84	0.82	-0.31	0.01	0.01
84	-2.27	0.30	-4.85	2.26	1.17	1.06	-0.58	0.28	-0.23	-0.28	-0.05
85	-2.32	-0.67	-4.51	1.57	1.01	1.27	-0.16	-0.12	-0.02	-0.37	0.08
86	-2.39	-2.44	-3.34	0.76	0.74	1.35	0.02	-0.39	-0.08	-0.14	0.06
87	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
88	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
89	-0.94	-3.70	-0.60	1.13	-0.23	0.29	-0.62	-0.31	-0.05	-0.12	0.24
90	-1.44	-3.77	-0.59	2.35	0.25	0.96	-0.44	0.12	0.17	-0.28	0.05
91	-2.28	-3.06	-0.62	2.70	0.53	0.86	0.19	0.03	0.29	-0.06	-0.02
92	-2.36	-2.27	-0.80	1.91	0.36	0.68	0.45	0.41	-0.07	0.05	-0.16
93	-2.68	-1.44	0.12	0.75	0.0	0.50	0.29	0.28	-0.0	0.09	0.11
94	-2.08	-1.02	1.16	0.45	-0.02	0.45	-0.45	-0.08	0.35	0.02	0.07
95	-2.75	-1.05	1.94	1.02	-0.06	0.46	-0.63	-0.08	0.53	-0.02	0.01
96	-2.79	-1.38	1.74	1.21	0.08	0.43	-0.62	-0.38	0.94	-0.21	-0.11
97	-3.65	-2.13	0.09	0.05	-0.93	-0.02	-0.96	-0.75	0.23	-0.37	0.12
98	-1.65	-1.40	-0.20	-0.04	0.06	1.13	-0.82	-0.55	0.37	-0.10	0.17
99	-0.61	-0.72	-1.50	-0.47	0.49	1.19	-1.05	-0.21	0.46	-0.17	-0.01

Table D.1. cont'

100	0.38	-0.51	-1.96	-0.72	0.68	0.52	-0.77	0.03	0.22	-0.36	0.18
101	0.39	0.49	-1.84	-0.27	0.79	0.37	-0.30	0.31	-0.03	-0.16	0.10
102	-0.09	0.67	-1.83	0.33	0.95	0.28	-0.16	0.24	0.08	0.0	0.16
103	-0.29	1.34	-0.76	1.00	0.67	-0.12	-0.24	0.63	-0.44	0.12	0.13
104	-0.42	1.14	0.33	0.70	0.66	-0.52	-0.30	0.16	-0.93	0.49	0.13
105	-0.97	0.48	1.28	0.51	1.47	-0.67	-0.09	0.36	-0.46	0.26	-0.20
106	-0.65	-0.08	1.36	0.58	1.91	-0.28	-0.12	0.43	-0.25	-0.02	-0.03
107	-0.81	-0.73	0.29	0.67	2.10	-0.07	-0.32	0.32	0.17	0.14	0.05
108	-0.29	-1.29	-0.50	0.77	1.78	-0.21	-0.65	0.31	0.17	0.04	-0.04
109	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
110	0.07	-2.17	-2.56	0.39	2.26	-1.03	-0.45	-0.27	-0.03	0.13	0.24
111	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
112	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
113	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
114	1.10	-1.99	-4.64	0.30	1.45	-1.00	-0.67	0.04	0.24	-0.42	0.26
115	0.76	-1.56	-4.30	0.66	0.70	-0.71	-0.65	-0.21	0.62	-0.46	0.27
116	0.49	-2.01	-3.91	1.27	-0.09	0.21	-0.48	-0.09	0.54	-0.43	0.27
117	0.41	-2.37	-3.19	1.96	-0.50	0.27	-0.43	-0.20	0.18	-0.01	0.14
118	0.21	-2.89	-2.59	1.97	-1.10	0.08	-0.27	-0.29	0.32	0.06	0.15
119	0.01	-2.75	-2.40	1.92	-1.03	-0.0	-0.12	0.08	0.17	0.29	0.13
120	-0.26	-2.64	-1.91	2.13	-0.80	-0.40	0.03	0.25	0.15	0.11	-0.16
121	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
122	-0.41	-1.92	-0.46	2.86	-1.19	-0.39	-0.14	0.21	0.14	-0.22	0.08
123	-0.15	-1.06	0.06	2.96	-1.48	0.05	-0.31	0.29	0.02	-0.10	-0.05
124	-0.58	-1.00	-0.01	2.94	-1.09	0.24	-0.28	0.22	-0.17	0.01	-0.04
125	-0.04	-1.47	-0.19	2.08	-1.02	-0.13	-0.25	-0.10	-0.05	0.31	0.02
126	1.13	-1.71	-0.10	1.45	-0.64	-0.46	-0.67	-0.32	0.08	0.32	-0.10
127	1.29	-1.90	0.04	0.91	-0.20	-0.87	-0.83	-0.37	0.09	0.13	0.13
128	1.30	-2.60	0.27	1.05	0.15	-1.27	-0.53	-0.0	-0.11	-0.02	0.34
129	0.87	-2.67	0.40	0.81	0.42	-1.32	0.17	0.27	-0.57	0.15	0.29
130	0.71	-2.83	0.19	0.81	0.64	-0.70	0.29	0.56	-0.76	0.40	0.11
131	0.22	-3.07	0.12	1.23	1.03	-0.71	0.36	0.57	-0.45	-0.11	0.09
132	-0.76	-3.55	0.05	1.29	1.15	-0.78	0.51	0.53	-0.13	-0.56	0.32
133	-1.56	-3.77	0.16	0.90	0.98	-0.91	0.33	0.27	-0.09	-0.21	0.13
134	-2.94	-3.88	-1.07	0.89	0.38	-0.22	-0.03	0.30	-0.36	0.11	-0.14

Table D.1. cont'

135	-3.59	-3.77	-1.29	0.49	-0.14	-0.35	0.06	0.03	-0.09	-0.05	-0.03
136	-3.25	-3.58	-2.38	0.06	-0.57	-0.32	0.41	-0.14	0.24	0.03	0.22
137	-3.09	-3.61	-2.45	-0.24	-0.66	-0.03	0.63	0.08	-0.29	0.38	-0.16
138	-2.92	-3.73	-2.62	-0.06	-0.72	0.64	0.76	0.17	-0.78	0.25	-0.15
139	-2.48	-3.40	-2.41	0.15	-0.71	0.53	0.82	-0.29	-0.71	-0.17	0.12
140	-2.16	-3.02	-1.99	0.38	-0.67	-0.22	1.12	-0.19	-0.38	-0.43	-0.02
141	-2.61	-3.14	-2.12	0.67	-0.38	-0.63	1.43	-0.22	-0.20	-0.27	-0.13
142	-2.29	-2.75	-1.85	1.19	0.09	-0.96	1.39	-0.18	-0.14	-0.03	-0.07
143	-2.53	-2.89	-1.79	1.43	0.45	-0.74	1.10	-0.16	0.06	-0.16	-0.05
144	-2.02	-2.63	-2.24	1.26	0.38	-0.15	0.68	-0.01	0.19	-0.34	0.08
145	-2.24	-2.31	-2.57	1.37	0.46	0.20	-0.42	-0.08	0.41	-0.13	0.19
146	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
147	-1.85	-2.24	-2.20	1.36	0.34	0.49	-0.85	0.0	0.05	0.04	0.05
148	-1.48	-1.85	-1.65	1.07	0.78	0.46	-0.55	0.34	-0.39	-0.18	0.09
149	-1.15	-1.02	-0.96	0.78	1.46	0.68	-0.42	0.42	-0.56	-0.37	0.03
150	-1.14	-1.48	-1.27	0.40	1.82	0.73	-0.39	0.25	-0.22	0.14	-0.17
151	-1.18	-1.25	-0.62	0.36	1.69	0.56	0.05	-0.17	-0.23	0.36	-0.19
152	-1.45	-1.45	-0.54	0.16	0.95	0.16	0.42	-0.10	0.25	0.01	-0.05
153	-1.79	-1.66	-0.03	0.02	0.14	-0.14	0.77	-0.19	0.23	-0.04	0.22
154	-1.97	-1.97	0.15	0.04	-0.73	-0.06	0.66	-0.04	-0.11	0.20	0.23
155	-1.91	-3.03	0.49	0.12	-0.98	-0.22	0.51	0.13	0.13	0.04	-0.0
156	-2.37	-3.72	0.89	0.89	-1.57	-0.50	0.66	0.30	0.10	-0.03	0.15
157	-2.72	-4.49	0.92	1.24	-1.47	-0.98	0.54	-0.03	0.07	-0.34	0.16
158	-2.72	-5.15	0.66	2.06	-1.04	-1.38	0.25	0.19	-0.08	-0.38	0.02
159	-2.63	-5.71	0.17	2.54	-0.23	-1.14	-0.55	0.09	0.08	0.04	-0.09
160	-2.77	-5.97	-0.50	2.99	0.15	-0.55	-0.74	0.17	0.08	0.43	-0.17
161	-2.77	-6.31	-0.28	3.24	0.11	-0.64	-0.52	0.29	0.23	0.05	0.05
162	-2.90	-6.41	-0.23	3.91	0.33	-0.81	-0.09	0.33	0.42	-0.45	0.26
163	-3.01	-6.35	-0.02	4.25	0.18	-0.92	0.23	0.49	0.25	-0.55	0.12
164	-3.21	-6.00	-0.47	4.09	0.02	-0.54	0.16	0.42	0.06	-0.12	-0.16
165	-3.72	-4.70	-0.42	3.82	-0.29	0.14	0.38	0.31	-0.03	-0.22	-0.29
166	-4.38	-3.59	-1.16	3.90	-0.51	0.42	0.36	0.04	-0.09	-0.01	-0.23
167	-5.07	-2.82	-2.00	3.23	-1.46	0.43	0.43	-0.35	0.02	0.09	-0.08
168	-5.34	-2.11	-2.82	2.96	-2.36	0.55	0.01	0.01	0.09	0.37	-0.09
169	-5.78	-2.29	-3.10	2.48	-2.04	1.19	0.10	0.69	-0.07	0.07	-0.24

Table D.1. cont'

170	-5.27	-3.06	-2.58	1.77	-1.48	1.50	0.02	0.81	-0.16	-0.10	-0.29
171	-5.69	-1.83	-1.99	1.23	-0.63	1.37	-0.19	0.56	-0.39	0.02	-0.04
172	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
173	-6.17	-0.30	-1.27	0.56	0.01	0.36	0.36	0.32	-0.08	-0.02	-0.19
174	-6.38	0.01	-1.81	0.37	0.08	-0.15	0.58	0.07	0.02	-0.30	-0.09
175	-6.78	-0.13	-2.05	0.56	0.22	-0.37	0.69	-0.20	0.18	-0.26	0.15
176	-6.26	-0.20	-1.76	0.57	0.47	-1.29	0.70	-0.33	0.12	-0.08	0.03
177	-6.38	-0.63	-1.25	0.64	0.47	-1.94	0.88	0.09	-0.12	0.20	-0.04
178	-6.08	-0.39	-1.76	0.67	0.20	-2.10	0.88	0.37	0.03	0.0	-0.20
179	-5.93	0.14	-2.35	1.25	0.30	-2.28	0.82	0.43	0.06	-0.20	-0.36
180	-5.52	-0.12	-3.24	0.99	0.68	-1.88	1.19	0.03	0.04	0.04	-0.14
181	-4.68	-0.15	-3.48	1.54	1.19	-1.12	0.98	-0.53	-0.02	0.0	0.09
182	-3.56	-0.03	-3.86	1.94	1.48	-0.24	0.66	-0.60	0.31	0.02	0.14
183	-3.95	-0.09	-3.08	1.95	1.97	0.31	0.44	-0.56	0.15	0.09	0.18
184	-2.95	-0.25	-1.70	1.90	2.19	0.54	0.30	-0.57	0.07	0.14	-0.06
185	-2.20	-0.18	-0.59	1.35	2.24	0.81	0.25	0.23	-0.21	0.02	-0.32
186	-1.84	-0.01	-0.23	1.20	2.20	0.52	-0.07	0.11	0.24	-0.39	0.16
187	-2.06	-0.32	-0.11	1.03	1.78	0.72	-0.77	0.27	-0.21	0.04	-0.11
188	-2.94	-0.96	-0.78	0.54	1.07	0.78	-0.70	0.36	0.38	0.20	-0.11
189	-3.35	-0.48	-0.89	0.49	0.52	0.51	0.45	-0.05	0.11	0.28	-0.18
190	-3.98	-0.11	-0.63	0.42	0.37	0.20	1.20	0.68	-0.33	0.07	-0.18
191	-4.46	0.24	-0.10	0.25	0.36	-0.77	0.90	0.72	0.22	0.08	0.14
192	-4.11	0.02	0.03	-0.47	1.54	-0.71	0.39	0.58	0.31	-0.08	-0.04
193	-4.45	-0.37	0.48	-1.23	2.71	-0.60	0.30	0.17	0.05	-0.06	0.14
194	-4.53	-0.45	0.27	-2.04	2.88	0.10	0.47	0.25	-0.16	-0.07	-0.10
195	-3.62	-0.05	0.71	-2.36	2.66	0.54	0.83	0.27	-0.04	-0.35	0.07
196	-3.88	0.60	0.72	-2.57	1.70	0.76	0.70	0.24	0.60	-0.16	-0.02
197	-3.06	0.68	1.50	-2.60	1.10	0.40	0.84	-0.23	0.47	0.22	-0.31
198	-2.79	0.60	1.90	-2.66	0.77	-0.07	0.64	-0.25	-0.52	0.33	0.19
199	-2.42	-0.44	2.42	-2.47	-0.42	-0.25	-0.12	-0.33	-0.55	-0.04	0.33
200	-1.90	-1.80	2.89	-1.93	-0.59	-0.68	-0.83	-0.72	0.28	0.27	-0.16
201	-1.93	-2.70	3.32	-1.57	-2.71	-1.29	-0.80	0.07	0.33	0.30	0.19
202	-2.51	-2.91	3.35	-1.78	-2.68	-0.95	-0.65	1.06	-0.05	-0.53	0.40
203	-2.79	-3.54	3.33	-2.03	-2.28	-0.25	-0.23	1.13	-0.35	-0.18	-0.09
204	-2.49	-4.28	2.93	-2.00	-1.56	0.52	0.44	0.23	-0.23	0.17	-0.26

Table D.1. cont'

205	-2.89	-4.50	2.78	-1.65	-0.78	1.13	0.34	-0.51	-0.31	-0.28	0.18
206	-3.05	-4.61	2.78	-0.87	-0.40	0.59	0.21	-0.46	-0.49	-0.01	0.18
207	-3.28	-4.08	2.64	-0.85	-0.27	0.17	-0.25	0.40	-0.42	0.09	-0.23
208	-3.66	-3.44	1.94	-1.38	0.18	0.20	-0.10	0.37	0.04	-0.11	-0.17
209	-4.24	-3.58	1.72	-1.46	0.92	0.53	0.74	-0.15	-0.15	-0.28	-0.03
210	-4.35	-3.84	1.40	-0.86	1.40	0.20	1.10	-0.31	-0.44	-0.27	0.07
211	-4.47	-3.47	1.11	-0.30	1.50	-0.16	1.00	-0.01	-0.25	0.11	-0.11
212	-4.07	-3.42	0.62	0.14	1.25	-0.53	0.66	0.18	-0.28	0.30	-0.10
213	-3.55	-2.89	0.29	-0.01	0.90	-0.14	0.17	0.16	-0.18	0.13	0.17
214	-3.64	-2.45	-0.28	0.09	0.20	0.52	-0.29	-0.04	0.01	-0.09	-0.09
215	-3.41	-1.92	-0.44	0.58	-0.13	0.82	-0.21	0.07	0.19	0.19	-0.12
216	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
217	-3.09	-1.68	-0.98	1.94	-0.46	1.21	-0.35	0.59	-0.54	-0.06	0.01
218	-3.16	-1.25	-1.51	2.75	-0.50	1.13	-0.91	0.82	0.09	-0.04	-0.07
219	-3.49	-0.56	-2.14	3.17	-0.77	0.95	-0.95	0.94	0.22	-0.17	0.33
220	-3.50	0.36	-2.94	3.34	-0.42	0.57	-0.82	0.69	0.19	0.17	0.22
221	-3.82	0.83	-3.36	3.32	-0.05	0.01	-1.10	0.72	0.0	0.45	-0.05
222	-2.98	1.79	-3.99	2.77	0.19	0.13	-1.13	0.58	0.03	0.32	-0.03
223	-3.05	2.36	-3.96	1.96	0.39	0.61	-0.80	-0.12	-0.01	0.22	0.0
224	-3.13	2.73	-3.55	1.15	0.59	0.70	-0.09	-0.04	-0.39	-0.01	-0.02
225	-4.05	2.88	-2.66	0.26	0.73	0.48	0.71	0.16	-0.59	-0.24	-0.17
226	-4.28	2.71	-1.61	-0.43	0.82	0.68	1.07	0.62	-0.47	-0.10	-0.14
227	-4.74	1.92	-0.90	-0.43	0.30	1.14	1.47	0.68	-0.11	-0.04	0.07
228	-6.65	1.32	-0.86	-0.20	0.37	1.26	1.42	0.54	0.02	0.12	0.11
229	-7.32	1.27	0.0	0.15	0.36	0.68	0.67	0.05	0.04	0.10	0.06
230	-7.55	1.32	0.58	0.08	-0.17	0.22	0.04	-0.47	0.09	-0.16	-0.29
231	-7.57	1.76	0.32	0.23	-0.74	0.26	-0.52	-0.60	-0.07	0.15	-0.28
232	-7.25	1.97	-0.65	0.03	-1.10	0.18	-0.62	0.20	-0.11	0.04	-0.10
233	-6.58	1.92	-1.48	-0.19	-1.06	0.48	-0.70	0.96	0.00	-0.20	-0.08
234	-6.04	1.16	-2.74	-0.75	-0.03	1.05	-0.71	0.30	-0.01	0.13	0.00
235	-5.38	0.88	-2.77	-0.70	0.41	0.98	-0.29	0.04	-0.21	0.13	0.24
236	-5.44	0.23	-2.76	-0.74	-0.21	0.70	0.20	0.03	-0.15	0.16	-0.25
237	-5.46	-0.11	-2.08	-0.28	-0.36	0.73	0.39	-0.26	-0.31	0.26	-0.19
238	-4.90	-1.21	-1.81	-0.03	-0.10	0.29	0.39	-0.26	-0.27	0.24	-0.12
239	-4.30	-1.82	-1.46	0.46	0.77	0.30	0.01	-0.07	-0.42	0.20	0.04
240	-3.24	-2.18	-1.62	0.53	1.41	0.13	-0.04	-0.05	-0.31	-0.16	0.04

Table D.2. Values of BAMPL for NUMB = 240

ROW	Wave Number		3	4	5	6	7	8	9	10	11
	1	2									
1	0.90	3.59	-3.33	-1.96	2.03	0.65	-0.66	0.30	-0.17	-0.18	0.11
2	0.96	1.94	-2.52	-1.93	1.67	-0.29	-0.74	0.47	0.38	-0.22	0.23
3	1.23	0.99	-0.53	-1.56	1.00	-0.47	-0.34	0.21	-0.04	-0.12	0.04
4	0.98	1.25	0.53	-1.47	0.38	-0.14	-0.10	-0.48	-0.52	0.11	0.07
5	0.73	1.78	1.45	-1.65	0.34	-0.15	-0.04	-0.42	-0.43	0.33	-0.01
6	-0.10	2.40	2.11	-1.75	-0.14	-0.23	0.76	-0.20	-0.08	0.10	-0.07
7	-0.72	3.40	2.14	-1.24	-1.22	0.35	0.86	-0.11	0.29	-0.32	-0.0
8	-1.53	4.11	2.25	-1.04	-2.08	1.12	0.30	0.18	0.37	-0.10	0.26
9	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
10	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
11	-2.51	2.85	3.47	-1.66	-0.37	0.42	-0.57	-0.44	0.53	0.08	0.13
12	-3.08	2.18	3.80	-1.43	0.63	0.0	-0.71	-0.59	0.47	0.06	0.02
13	-3.14	2.29	3.96	-1.04	1.12	-0.46	-0.88	-0.45	-0.17	-0.20	0.25
14	-3.43	3.23	3.89	-0.65	1.38	-0.59	-1.24	-0.18	-0.27	0.04	0.12
15	-3.52	4.18	3.72	-0.70	1.24	-1.00	-0.94	0.26	-0.09	0.10	-0.10
16	-3.93	4.94	3.25	-0.42	1.07	-1.30	0.21	0.16	0.23	-0.22	0.06
17	-4.05	5.59	2.44	-0.11	0.95	-1.10	0.92	-0.36	-0.13	-0.14	0.05
18	-4.98	5.93	1.50	0.85	0.42	-0.85	1.14	-0.68	-0.03	0.15	-0.08
19	-4.99	5.83	0.61	1.28	-0.47	-0.04	0.21	-0.80	0.18	-0.11	-0.07
20	-5.41	5.20	-0.13	1.76	-0.85	1.00	-0.88	-0.15	-0.13	0.01	-0.26
21	-6.20	5.50	-1.01	1.70	-1.05	1.30	-1.20	0.31	-0.81	0.24	-0.32
22	-7.05	6.50	-2.00	1.67	-0.90	1.51	-0.66	-0.07	-0.52	-0.13	-0.27
23	-7.32	6.61	-2.89	1.64	-0.48	1.68	-0.36	-0.29	0.18	-0.34	0.29
24	-7.94	7.02	-3.17	1.72	0.49	1.08	-0.24	-0.16	0.47	-0.11	0.04
25	-7.46	7.17	-2.28	0.95	0.52	0.60	0.15	0.04	0.40	0.03	-0.18
26	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
27	-7.45	7.31	-1.46	1.29	-0.61	0.70	0.47	-0.78	0.71	-0.13	-0.01
28	-7.21	8.08	-1.91	1.17	-0.89	0.65	-0.31	-0.37	0.64	-0.37	0.02
29	-6.95	8.27	-2.69	0.68	-1.24	1.27	-0.95	-0.23	-0.12	0.33	0.16

Table D.2. Cont'

30	-7.25	8.09	-2.83	0.70	-1.13	1.09	-0.77	-0.37	-0.43	0.29	-0.37
31	-6.83	7.48	-2.29	0.27	-1.16	0.24	-0.06	0.15	-0.53	-0.10	-0.26
32	-6.40	6.77	-1.49	0.05	-0.76	-0.05	-0.04	0.28	-0.17	-0.21	-0.32
33	-6.08	6.41	-1.13	-0.15	0.12	-0.53	-0.12	0.38	0.05	0.09	-0.11
34	-5.37	6.93	-0.65	-0.32	0.31	-0.49	0.46	-0.02	-0.21	0.09	0.08
35	-4.37	7.05	-0.11	-0.91	0.35	-0.33	0.76	-0.66	-0.12	0.02	0.03
36	-3.80	6.89	-0.15	-0.96	0.11	0.46	0.69	-0.87	0.14	-0.04	0.17
37	-2.75	6.92	-0.61	-1.31	0.40	1.23	0.18	-0.65	0.35	0.08	0.17
38	-2.48	6.48	-1.22	-1.06	0.43	1.42	-0.24	-0.35	0.33	0.05	-0.11
39	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
40	-3.03	5.31	-2.31	-0.36	0.10	1.34	-0.63	0.33	-0.58	-0.13	-0.24
41	-3.31	4.94	-2.21	-0.48	0.12	0.80	-0.03	0.03	-1.02	0.23	-0.0
42	-3.51	4.42	-1.81	-1.29	0.84	0.16	0.24	-0.43	-0.61	0.48	0.01
43	-3.17	4.22	-1.69	-1.74	1.37	-0.38	0.40	-0.73	0.09	0.26	-0.16
44	-3.34	3.82	-2.01	-1.99	1.43	-0.92	0.47	-0.39	0.44	-0.23	-0.29
45	-3.00	3.83	-2.39	-1.55	1.26	-0.87	0.52	-0.34	0.35	-0.63	0.09
46	-2.20	3.11	-2.25	-1.53	0.86	-0.23	0.21	-0.58	0.17	-0.47	0.27
47	-1.02	2.99	-1.99	-1.47	0.12	0.30	0.10	-0.77	-0.39	-0.34	0.17
48	-0.71	2.31	-1.62	-0.93	-0.20	0.45	-0.13	-0.34	-0.41	-0.32	-0.14
49	-0.19	1.35	-0.90	-0.18	-0.83	0.44	-0.31	-0.31	0.30	-0.28	-0.21
50	-0.92	0.59	-0.68	0.22	-0.84	0.65	-0.15	-0.48	0.48	-0.22	-0.17
51	-1.42	-0.53	-0.28	0.67	-0.40	-0.12	0.05	-0.26	0.28	0.13	-0.11
52	-1.98	-1.17	0.39	1.24	-0.23	-0.03	0.16	-0.33	0.46	-0.28	0.02
53	-2.43	-1.92	1.42	1.09	0.99	-0.41	0.28	-0.50	0.05	0.0	0.12
54	-2.00	-2.93	2.03	0.70	1.46	-0.19	-0.24	-0.69	-0.33	0.38	-0.19
55	-0.92	-3.73	2.28	0.46	1.79	0.16	-0.58	-0.60	-0.29	0.38	0.11
56	-0.52	-4.93	2.79	0.03	1.65	-0.15	-0.96	-0.18	0.11	-0.06	0.19
57	0.26	-5.64	3.17	0.36	1.46	-0.65	-0.79	-0.24	0.58	-0.31	0.18
58	0.42	-5.66	2.92	-0.0	1.13	-0.84	-0.86	-0.31	0.55	-0.33	-0.07
59	0.55	-5.47	2.67	-0.68	1.17	-0.97	-0.27	-0.39	0.29	-0.16	-0.17
60	0.18	-4.62	1.89	-0.67	2.12	-1.23	-0.01	-0.04	0.27	-0.32	-0.40
61	-0.27	-3.24	0.70	-1.20	1.99	-0.96	0.37	-0.20	0.54	-0.19	-0.13
62	-1.67	-1.66	-0.15	-0.73	1.53	-0.17	0.71	-0.43	0.44	-0.13	-0.07
63	-2.68	-0.27	-0.18	-0.46	0.84	0.27	0.99	-0.44	0.11	0.23	0.0
64	-3.74	1.20	-0.56	0.12	0.35	0.25	0.77	-0.07	-0.06	0.23	0.0

Table D.2. Cont'

65	-4.80	2.86	-0.65	0.56	-0.0	0.30	0.35	0.46	0.09	0.01	0.01
66	-5.77	4.10	-1.35	0.61	-0.32	1.04	0.09	0.44	-0.03	0.03	-0.04
67	-6.08	5.67	-1.90	1.05	-0.51	1.69	-0.14	0.33	-0.01	0.24	0.08
68	-5.87	6.62	-2.59	0.79	-0.44	1.56	-0.07	0.04	0.24	-0.10	0.17
69	-4.77	7.62	-3.04	-0.29	0.02	1.69	0.04	0.38	0.05	-0.30	0.05
70	-4.54	7.31	-3.12	-0.60	0.41	2.03	-0.02	0.40	-0.30	-0.02	0.03
71	-3.68	7.04	-3.12	-1.43	0.99	1.76	0.48	-0.36	-0.02	0.15	0.28
72	-2.37	6.28	-2.73	-2.03	1.73	0.64	0.42	-0.41	0.16	0.62	-0.0
73	-0.90	5.77	-1.83	-2.35	1.47	0.45	0.24	-0.18	0.66	0.01	-0.08
74	-0.21	5.25	-1.66	-2.38	0.73	0.33	-0.11	0.17	0.38	-0.32	-0.13
75	0.36	5.42	-1.65	-2.20	-0.18	0.69	-0.36	0.39	-0.16	-0.45	0.25
76	-0.09	5.76	-1.80	-1.64	-0.95	1.21	-0.30	0.38	-0.38	-0.14	0.29
77	0.70	4.88	-1.49	-1.32	-0.92	0.75	0.25	0.22	-0.36	-0.13	0.27
78	1.08	3.46	-0.84	-1.90	-0.23	-0.24	0.37	-0.27	-0.06	-0.18	0.03
79	0.88	2.46	0.12	-1.81	0.71	-0.50	0.60	-0.23	0.28	0.04	-0.31
80	0.57	1.59	1.10	-1.53	1.49	-0.26	0.96	-0.07	0.58	0.42	-0.36
81	0.82	0.71	2.22	-1.84	1.53	-0.13	0.99	0.14	0.25	0.53	-0.14
82	0.52	0.22	3.18	-2.17	1.18	-0.30	0.48	0.10	0.04	0.34	0.34
83	0.24	-0.35	3.24	-2.74	1.17	-0.64	-0.02	-0.03	0.0	0.10	0.25
84	-0.52	-0.54	2.76	-3.34	1.62	-0.56	0.04	-0.32	0.22	-0.03	-0.10
85	-0.94	-0.85	2.26	-3.57	1.51	-0.30	0.28	-0.43	0.31	0.06	-0.12
86	-1.07	-0.42	2.52	-3.70	0.86	-0.99	0.42	-0.50	0.39	0.01	0.28
87	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
88	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
89	-1.74	1.09	0.25	-2.37	1.84	0.50	-0.15	-0.46	0.14	-0.25	-0.09
90	-1.77	1.98	-1.00	-2.58	1.65	1.07	-0.38	-0.27	0.56	0.35	0.07
91	-1.39	2.42	-1.31	-2.88	1.67	1.15	-0.79	-0.04	0.35	0.23	-0.04
92	-1.00	2.51	-1.09	-2.95	1.13	1.00	-1.25	0.46	0.24	0.15	0.05
93	-0.33	2.74	-0.61	-1.78	1.20	1.32	-1.37	0.32	0.12	0.07	0.20
94	-1.03	2.06	-1.78	0.23	1.01	1.63	-1.03	0.04	0.11	0.09	0.16
95	-1.84	1.41	-3.58	1.39	1.30	1.27	-0.66	-0.16	0.23	-0.06	0.30
96	-2.10	0.99	-4.36	1.29	1.05	0.15	-0.52	-0.0	0.32	0.16	-0.04
97	-1.55	0.89	-4.11	0.82	1.10	-0.27	-0.09	0.39	0.47	-0.24	0.25
98	-1.61	1.37	-3.66	0.12	0.65	-0.22	0.49	-0.13	0.43	-0.43	0.28
99	-1.02	2.11	-2.85	-0.70	0.47	0.20	0.13	-0.34	0.68	-0.11	0.02

Table D.2. Cont'

100	-1.52	2.10	-2.18	-0.63	0.85	0.39	-0.45	-0.39	0.79	-0.09	-0.06
101	-1.70	1.86	-1.43	-0.47	1.27	0.44	-0.28	-0.48	0.70	-0.23	0.23
102	-2.03	1.57	-1.31	-0.58	1.57	-0.14	-0.30	-0.89	0.77	-0.16	0.0
103	-2.01	1.44	-1.93	-0.86	1.31	-0.46	-0.18	-0.69	0.59	-0.37	-0.09
104	-1.97	0.71	-2.55	-0.68	1.01	0.12	-0.22	-0.24	-0.21	0.05	0.09
105	-1.26	0.44	-2.84	-0.54	1.03	0.47	0.24	-0.05	-0.48	0.60	0.04
106	-1.23	-0.11	-3.21	-0.76	0.43	0.57	0.34	0.41	-0.58	0.35	-0.22
107	-0.88	0.22	-3.23	-1.24	-0.32	0.28	0.23	0.41	-0.53	0.26	0.01
108	-1.50	0.72	-3.27	-1.57	-0.53	0.46	-0.06	0.10	-0.20	0.06	0.20
109	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
110	-1.30	1.81	-3.33	-2.56	-0.20	0.63	-0.11	0.12	-0.06	-0.42	0.02
111	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
112	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
113	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
114	-0.22	1.80	0.12	-3.20	1.84	0.68	-0.30	-0.01	0.07	0.01	0.02
115	-0.17	1.69	0.94	-2.50	1.84	0.87	-0.18	-0.18	0.36	-0.19	0.12
116	-0.68	1.67	1.27	-1.62	1.93	1.08	0.03	-0.25	0.54	-0.29	0.04
117	-0.79	2.00	0.92	-1.07	1.52	0.77	0.14	-0.26	0.46	-0.05	-0.12
118	-0.84	2.39	0.98	-0.90	1.67	0.21	0.42	-0.44	-0.07	0.04	-0.27
119	-0.52	2.90	0.77	-0.64	1.65	0.36	0.16	-0.49	-0.19	-0.24	0.17
120	-0.48	2.78	0.99	-0.80	1.53	0.63	-0.08	-0.49	-0.50	-0.0	-0.02
121	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
122	-0.77	2.42	0.45	-0.73	1.31	-0.40	0.65	-0.65	-0.02	-0.09	-0.14
123	-1.45	1.97	-0.58	-0.84	0.70	-0.59	0.72	-0.33	0.29	-0.03	-0.13
124	-2.24	1.75	-2.22	-1.26	0.07	-0.68	0.54	-0.26	-0.01	0.01	-0.21
125	-2.39	1.13	-3.13	-1.67	-0.35	-0.28	0.50	0.17	-0.25	0.19	-0.07
126	-2.66	0.82	-3.42	-1.92	-0.20	0.13	0.26	-0.14	-0.37	0.27	-0.10
127	-2.69	0.24	-3.42	-1.93	0.45	1.03	0.14	-0.42	0.22	0.09	-0.03
128	-2.96	-0.08	-3.35	-1.61	1.30	1.45	0.13	-0.44	0.52	-0.11	-0.11
129	-2.62	0.22	-2.69	-1.45	1.61	1.20	0.23	-0.26	0.50	-0.48	-0.26
130	-2.61	0.83	-2.43	-1.56	1.51	1.11	0.07	-0.16	-0.27	-0.20	-0.19
131	-2.27	1.13	-2.52	-1.59	1.28	1.06	-0.28	0.01	-0.52	0.09	-0.26
132	-2.36	0.85	-3.37	-1.65	0.92	0.46	-0.64	-0.23	-0.05	-0.33	0.19
133	-1.70	0.67	-3.46	-1.75	1.03	-0.28	-0.40	-0.31	0.30	-0.73	0.21
134	-1.25	0.89	-3.37	-1.51	0.97	-0.54	-0.34	-0.45	0.18	-0.36	0.06

Table D.2. Cont'

135	-0.42	1.46	-2.97	-0.67	1.03	-0.09	-0.93	0.06	-0.0	0.01	-0.20
136	-0.50	1.07	-3.30	-0.37	1.18	-0.04	-0.97	-0.37	0.24	-0.04	0.15
137	0.38	1.35	-3.31	0.56	1.24	-0.17	-0.91	-0.69	0.46	-0.02	0.12
138	0.33	1.13	-3.40	0.73	1.45	0.43	-0.91	-0.30	0.06	0.31	-0.31
139	0.42	1.09	-3.55	1.00	1.32	1.34	-0.83	-0.29	-0.54	0.23	-0.14
140	-0.15	1.20	-3.61	1.35	1.11	1.93	-0.61	-0.27	-0.51	0.02	0.07
141	-0.46	1.28	-3.31	1.64	1.15	1.41	-0.03	-0.23	-0.27	-0.13	-0.14
142	-1.29	1.04	-3.55	1.51	0.83	0.92	0.37	-0.17	-0.24	0.03	-0.06
143	-0.96	1.26	-3.14	1.54	0.58	0.07	0.89	-0.22	-0.19	0.28	-0.09
144	-1.09	0.51	-2.30	1.55	0.52	-0.53	1.25	0.18	-0.29	0.12	-0.27
145	-0.87	0.13	-2.06	1.94	0.67	-0.47	1.08	-0.16	-0.21	-0.01	0.14
146	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
147	-0.44	-0.60	-2.40	2.01	0.81	-0.44	-0.30	-0.31	0.38	-0.01	-0.01
148	-1.03	-0.69	-2.50	1.79	0.92	-0.47	-0.60	-0.26	0.07	0.34	-0.11
149	-0.86	-0.53	-2.26	1.43	1.44	-0.41	-0.32	0.14	0.01	-0.19	0.22
150	-0.78	-0.29	-3.20	0.76	1.72	0.12	-0.49	0.24	0.0	-0.23	0.10
151	-0.01	0.21	-3.75	0.05	2.36	0.51	-0.81	0.19	-0.01	0.12	-0.17
152	-0.28	0.30	-3.79	-0.41	2.84	0.64	-0.96	-0.16	-0.11	0.34	0.01
153	-0.09	0.47	-4.00	-0.70	2.68	0.45	-0.56	-0.34	0.07	-0.12	0.07
154	-0.73	1.37	-3.82	-1.64	1.99	0.45	0.02	-0.46	0.08	-0.20	0.08
155	-0.56	2.35	-3.32	-1.66	0.99	0.57	0.03	-0.57	-0.18	-0.07	-0.15
156	-1.51	2.83	-2.67	-1.71	0.24	0.38	0.02	-0.45	0.02	-0.10	-0.22
157	-1.89	3.74	-1.72	-1.51	-0.51	0.19	0.32	-0.52	0.09	0.01	0.05
158	-3.18	3.75	-1.03	-1.02	-0.89	-0.37	0.63	-0.30	0.11	-0.19	-0.01
159	-3.68	4.32	-0.75	-0.35	-1.12	-0.70	0.30	-0.36	0.06	-0.29	0.0
160	-3.80	4.44	-1.44	-0.09	-0.29	-0.64	-0.29	-0.52	0.07	0.08	-0.01
161	-3.25	4.50	-1.95	0.17	0.42	0.06	-0.76	-0.59	-0.35	0.33	-0.21
162	-3.15	4.44	-2.21	0.04	0.92	0.34	-0.67	-0.29	-0.28	0.21	-0.12
163	-2.27	4.22	-1.79	0.14	1.21	-0.14	-0.04	0.18	0.13	-0.43	0.22
164	-1.95	3.69	-0.89	0.29	1.62	-0.83	0.19	0.70	0.38	-0.19	0.08
165	-1.37	3.75	-0.36	0.67	1.58	-1.06	-0.32	0.59	0.26	0.09	-0.02
166	-1.67	3.65	-0.05	-0.11	1.86	-1.25	-0.30	0.46	0.17	0.25	-0.02
167	-1.52	4.07	-0.25	-0.24	1.89	-0.95	-0.08	-0.03	0.13	-0.02	0.14
168	-2.28	4.83	-0.65	-0.49	1.01	-1.08	0.13	-0.77	0.06	-0.03	0.14
169	-2.06	5.10	-1.19	-0.24	0.03	-1.07	0.18	-0.48	0.32	0.40	0.29

Table D.2. Cont'

170	-2.08	4.64	-1.64	0.35	-1.10	-0.38	0.18	-0.09	0.48	0.16	-0.03
171	-1.57	3.51	-1.90	0.30	-1.18	0.42	-0.01	0.26	0.37	0.02	-0.18
172	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
173	-1.85	1.96	-1.46	-0.27	-0.93	0.83	-0.67	-0.01	-0.42	0.30	0.25
174	-2.10	1.23	-0.90	-0.59	-0.84	0.92	-0.38	0.42	-0.16	0.26	-0.17
175	-1.48	1.23	-0.82	-0.30	-0.79	1.47	0.03	0.51	0.07	0.07	-0.04
176	-1.63	1.17	-0.85	0.15	-0.91	1.62	-0.31	0.01	-0.09	0.14	0.17
177	-0.93	1.06	-0.72	0.45	-1.21	0.91	-0.55	-0.40	-0.21	-0.01	0.01
178	-1.37	0.42	-0.63	0.20	-1.18	0.34	-0.40	-0.39	-0.30	0.13	0.04
179	-0.69	0.36	-1.14	0.31	-1.13	0.15	0.10	0.29	-0.05	-0.02	-0.03
180	-1.02	0.17	-1.36	0.78	-0.48	-0.30	0.51	0.60	0.0	0.21	-0.30
181	-1.54	0.76	-1.94	1.57	-0.53	-0.89	0.74	0.56	-0.34	0.24	-0.31
182	-2.13	0.65	-2.15	2.38	-0.38	-1.05	0.61	0.10	0.03	0.10	0.12
183	-1.96	0.35	-2.19	3.05	0.04	-0.65	0.75	-0.04	0.01	-0.14	0.15
184	-2.63	-0.60	-2.54	3.12	0.43	-0.12	0.51	-0.57	0.14	0.14	0.49
185	-1.88	-1.05	-2.85	3.25	0.75	0.35	0.61	-0.60	-0.13	0.47	0.04
186	-0.97	-1.28	-2.71	3.00	0.83	0.73	0.98	-0.11	-0.13	-0.07	0.08
187	0.65	-1.19	-2.55	2.77	1.37	0.64	0.60	-0.35	-0.04	-0.35	0.12
188	1.33	-1.53	-2.63	2.15	0.85	0.93	-0.76	0.09	-0.35	-0.33	-0.06
189	2.63	-1.60	-2.83	2.13	0.29	1.01	-1.40	-0.35	0.45	-0.11	-0.07
190	1.78	-1.91	-3.43	1.64	-0.25	1.44	-0.55	-0.38	0.11	0.33	-0.29
191	1.64	-1.42	-3.11	1.97	-1.06	0.80	0.13	0.04	-0.36	0.23	-0.06
192	-0.02	-0.96	-2.92	2.06	-1.67	-0.02	0.39	0.40	0.09	-0.0	-0.08
193	-1.38	-1.10	-3.20	2.33	-1.20	-0.45	-0.10	0.38	0.29	0.21	0.07
194	-2.92	-1.07	-3.51	1.92	0.23	-0.67	-0.49	0.36	0.34	0.22	0.03
195	-3.23	-0.76	-4.28	1.84	1.30	-0.52	-0.27	0.12	-0.22	-0.03	-0.02
196	-3.70	-0.01	-4.62	1.11	1.89	0.10	-0.13	0.40	0.08	-0.11	0.14
197	-2.81	0.87	-4.31	1.04	2.08	0.61	0.25	0.60	0.94	-0.27	-0.05
198	-2.69	1.67	-3.93	0.55	2.39	0.59	0.70	0.05	0.60	0.22	-0.22
199	-1.81	2.48	-3.62	-0.19	2.82	0.72	0.87	-0.15	-0.22	0.25	0.22
200	-1.57	2.46	-3.09	-0.97	2.57	0.75	0.66	-0.57	-0.40	-0.28	0.22
201	-0.10	2.20	-2.38	-0.58	1.26	0.24	-0.05	-1.32	0.16	0.33	-0.19
202	-0.26	2.46	-1.78	-0.48	-0.09	-0.73	-0.36	-0.79	0.44	0.47	0.23
203	0.70	3.06	-1.06	-0.95	-1.18	-1.03	-0.53	0.40	0.37	-0.44	0.25
204	0.04	3.37	-1.15	-1.32	-1.92	-1.01	-0.39	0.76	0.10	0.05	-0.11

Table D.2. Cont'

205	0.33	3.62	-1.45	-1.71	-2.05	-0.30	0.03	0.39	0.38	-0.01	-0.15
206	-0.62	3.39	-0.97	-1.61	-2.05	0.38	0.11	-0.39	-0.05	-0.16	0.23
207	-0.10	3.40	0.01	-1.17	-1.71	0.13	0.19	-0.48	-0.29	-0.02	0.17
208	-0.32	3.41	0.12	-1.20	-1.61	-0.27	-0.31	0.15	-0.08	-0.02	-0.04
209	0.20	3.80	-0.01	-1.82	-1.16	0.06	-0.61	0.29	0.45	-0.17	0.0
210	-0.62	3.34	-0.31	-2.59	-0.69	0.24	0.16	-0.13	0.16	-0.54	0.13
211	-0.92	3.77	-0.24	-2.69	-0.23	0.14	0.58	-0.26	-0.04	-0.48	0.12
212	-2.06	4.46	0.78	-2.54	0.11	-0.48	0.90	-0.01	-0.04	-0.04	-0.07
213	-2.05	4.92	1.09	-2.30	-0.01	-0.90	0.84	0.17	-0.09	0.10	0.17
214	-2.76	5.03	1.60	-2.28	0.10	-0.88	0.45	-0.12	-0.06	-0.28	0.22
215	-2.21	5.39	1.94	-2.28	-0.12	-0.52	0.15	-0.42	0.04	-0.20	0.12
216	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
217	-2.51	5.06	2.20	-2.37	-0.61	0.39	0.59	-0.32	-0.41	-0.30	0.01
218	-3.51	4.74	2.05	-2.39	-0.81	0.41	0.77	-0.11	-0.48	-0.24	-0.30
219	-3.69	4.80	2.19	-2.00	-1.17	0.47	0.52	0.07	-0.38	-0.22	-0.15
220	-5.13	4.47	1.77	-1.31	-1.32	0.44	0.23	0.18	-0.11	-0.26	0.04
221	-5.02	4.67	1.33	-0.22	-1.18	-0.19	0.18	0.08	0.05	-0.12	0.04
222	-5.87	4.01	0.21	0.33	-0.80	-0.73	-0.32	0.63	-0.24	-0.02	-0.09
223	-4.83	3.93	-0.43	0.75	-0.33	-1.02	-1.13	0.48	-0.11	0.16	-0.13
224	-4.77	3.55	-1.04	0.84	0.38	-1.11	-1.04	0.06	-0.06	0.31	-0.11
225	-3.37	3.48	-1.47	1.05	0.80	-1.30	-0.95	-0.20	-0.30	0.19	-0.0
226	-3.46	2.69	-1.31	0.43	1.87	-1.96	-0.35	-0.23	-0.43	0.03	-0.16
227	-2.26	2.88	-1.19	-0.03	1.80	-1.68	-0.05	0.20	-0.58	-0.12	-0.08
228	-1.98	2.48	-1.40	-0.22	1.48	-0.84	0.83	0.79	-0.25	-0.11	-0.06
229	-0.34	1.41	-1.55	-0.39	1.28	-0.29	0.86	0.66	-0.22	0.24	0.31
230	-0.74	0.01	-1.30	-0.55	1.28	0.08	0.72	0.34	0.02	0.17	0.19
231	-0.02	-0.72	-1.15	-0.16	0.43	0.51	0.28	-0.20	0.14	-0.02	-0.11
232	-0.55	-1.66	-0.66	-0.11	-0.36	0.46	0.04	-0.79	0.04	0.31	-0.03
233	0.35	-1.65	-0.34	-0.11	-1.55	0.15	-0.10	-0.03	-0.07	0.08	-0.12
234	0.36	-1.72	-0.21	-0.47	-1.92	0.49	-0.59	0.83	0.01	-0.16	-0.12
235	1.18	-1.44	-0.41	-0.88	-1.39	0.67	-0.86	0.63	0.02	-0.03	0.20
236	0.59	-1.27	-0.68	-1.14	-1.13	1.00	-0.74	0.63	-0.09	0.01	0.36
237	1.09	-0.35	-0.58	-1.20	-1.09	0.68	-0.36	0.33	-0.19	0.06	0.05
238	0.01	0.24	-0.10	-1.59	-1.10	0.57	0.22	0.17	-0.19	0.04	-0.07
239	0.08	1.27	-0.07	-1.04	-0.99	0.03	0.11	0.13	-0.13	0.22	0.04
240	-1.07	1.68	0.31	-1.12	-0.83	-0.26	-0.32	0.27	-0.47	0.26	-0.10

APPENDIX E

(Southern Data Set)

Figure E.1 to E.11.

Phase-angle versus Time for space-waves of wave number 1 to 11, respectively. Time is indicated as days after November 23, 1976. These angles are uncorrected, that is, the angles are restricted to values between ± 180 .

Figure E.1.

Wave Number 1

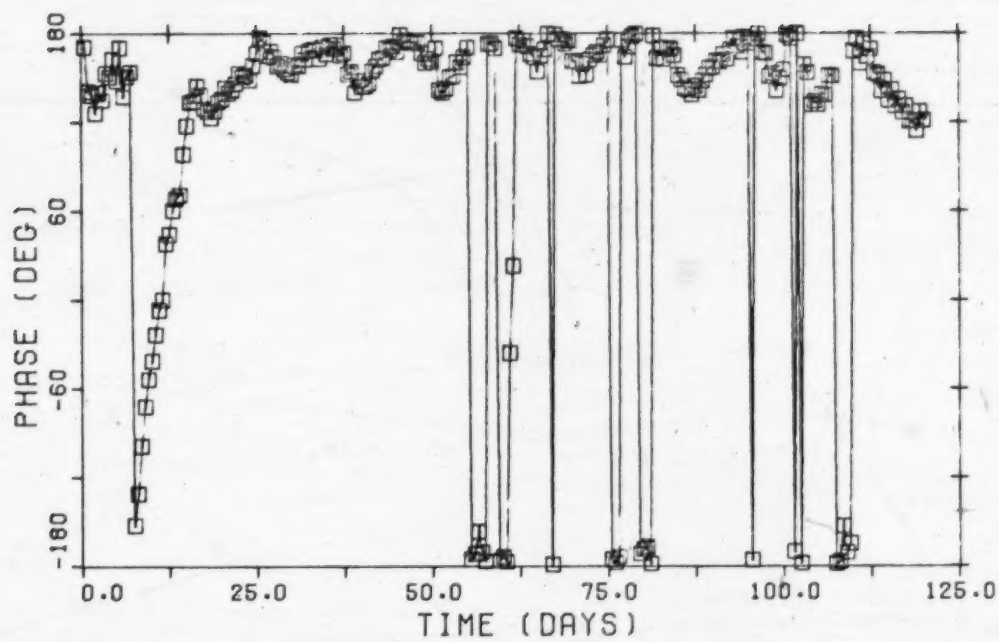


Figure E.2.

Wave Number 2

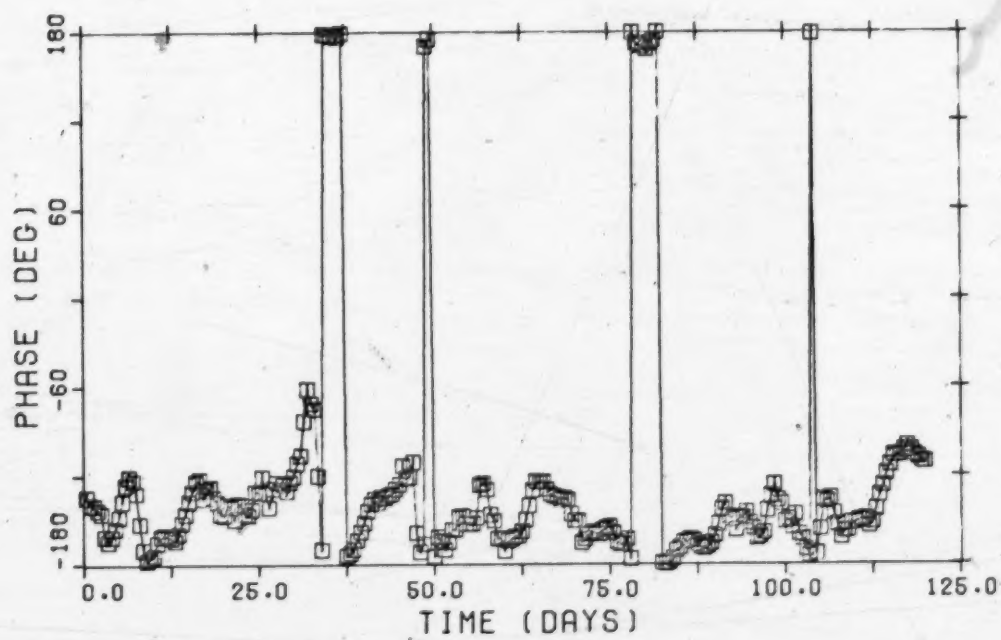


Figure E.3.

Wave Number 3

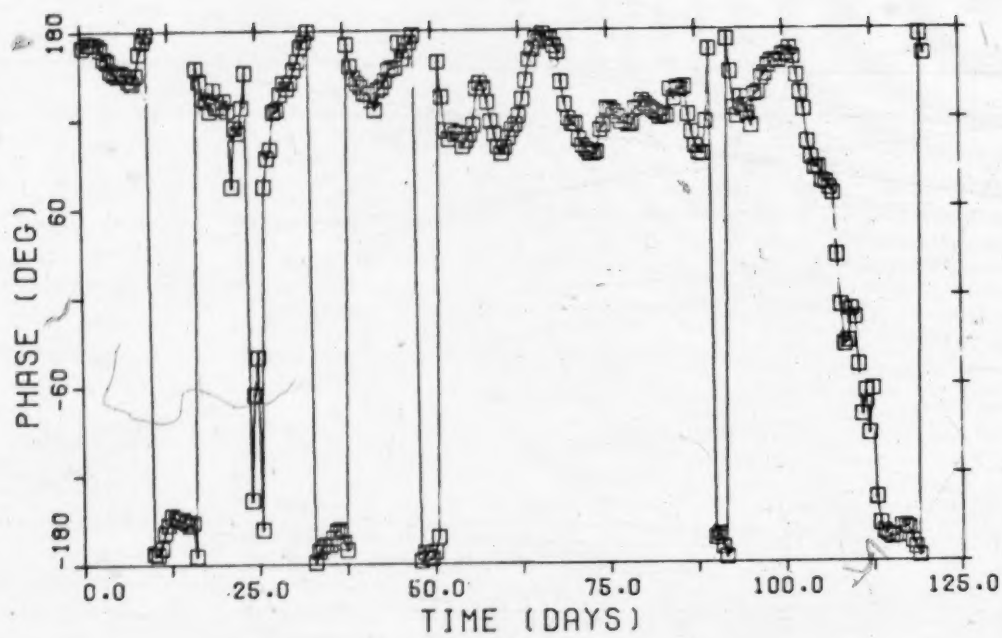


Figure E.4.

Wave Number 4

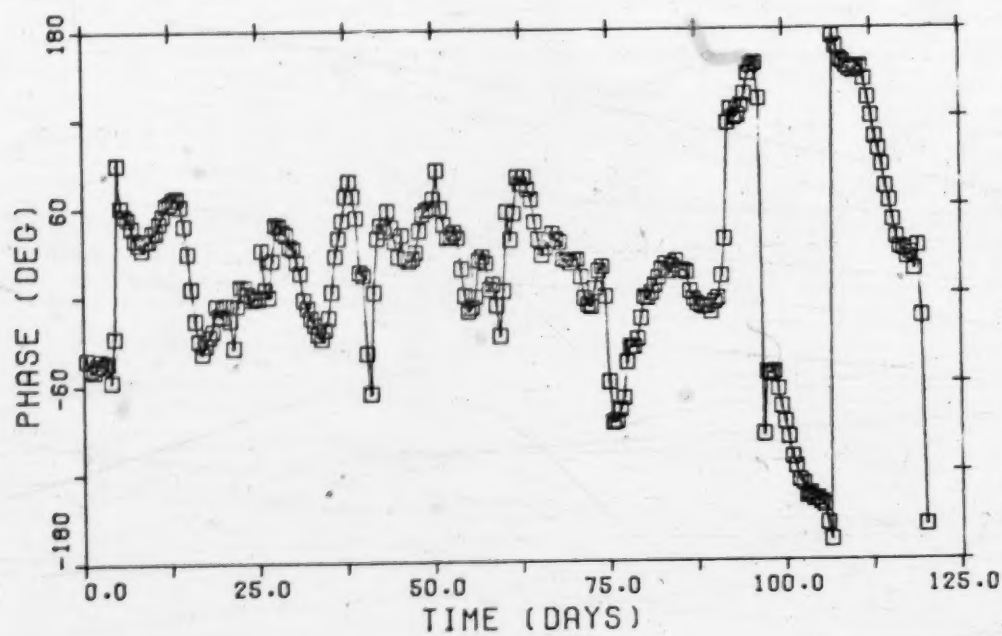


Figure E.5.

Wave Number 5

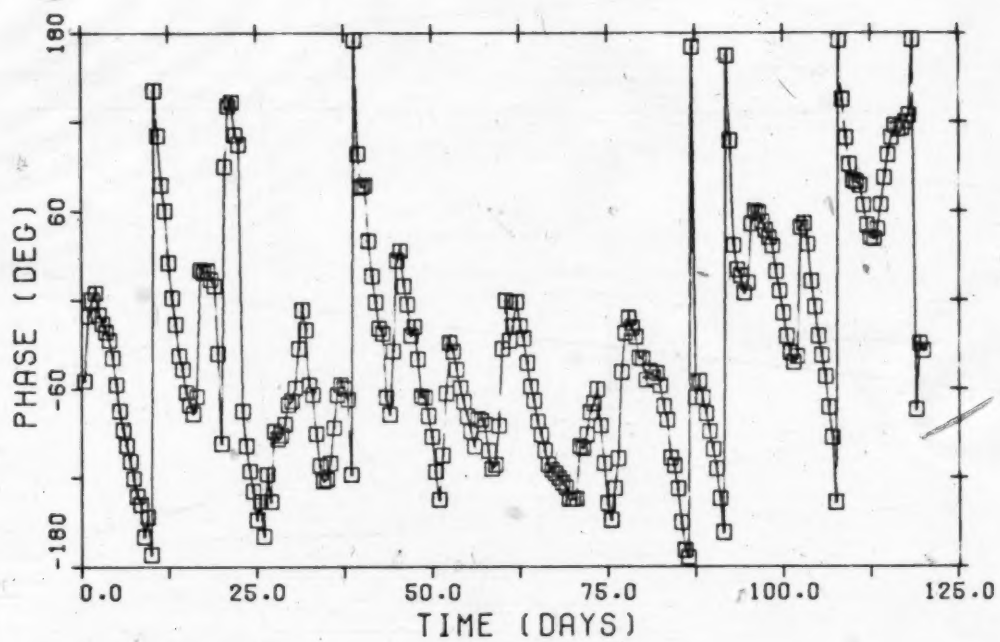


Figure E.6.

Wave Number 6

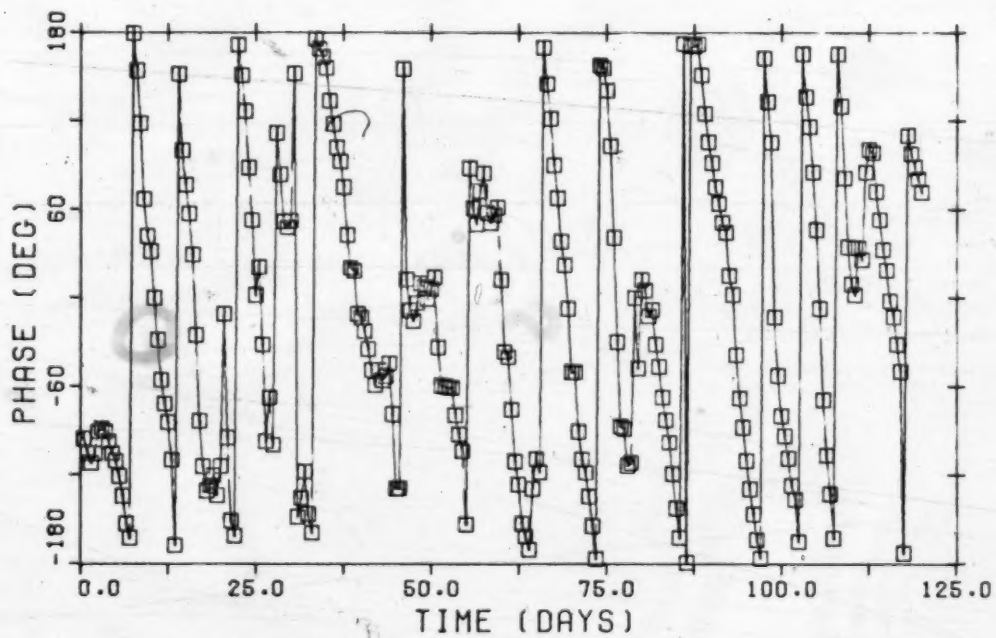


Figure E.7.

Wave Number 7

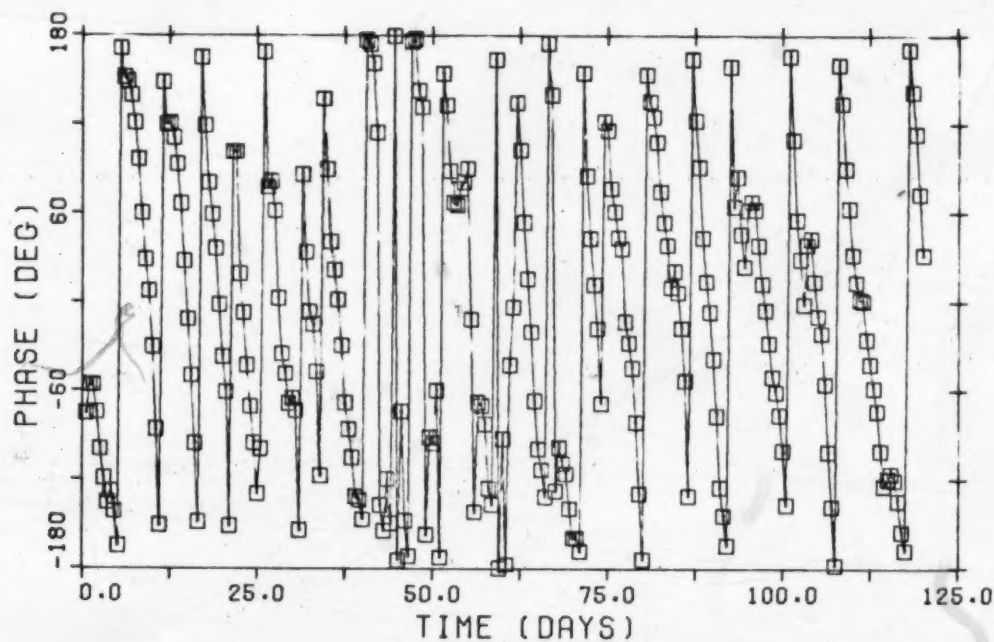


Figure E.8.

Wave Number 8

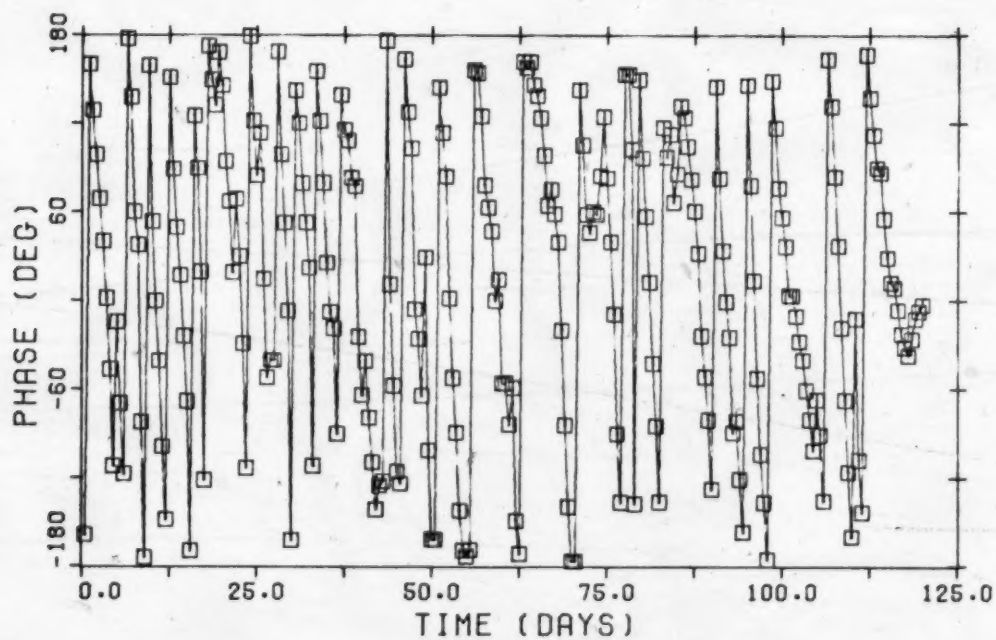


Figure E.9.

Wave Number 9

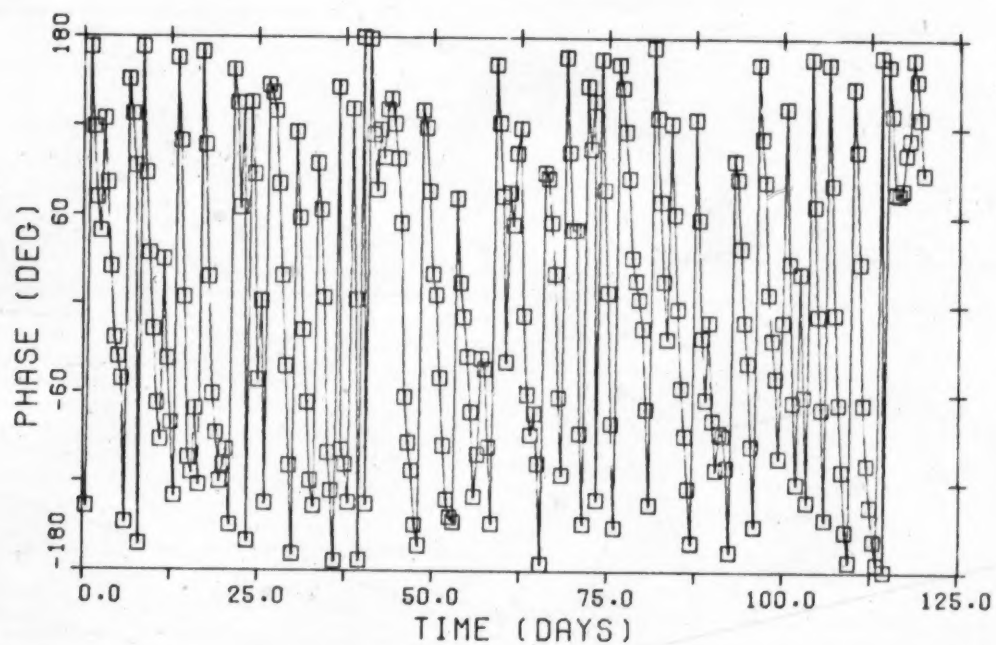


Figure E.10.

Wave Number 10

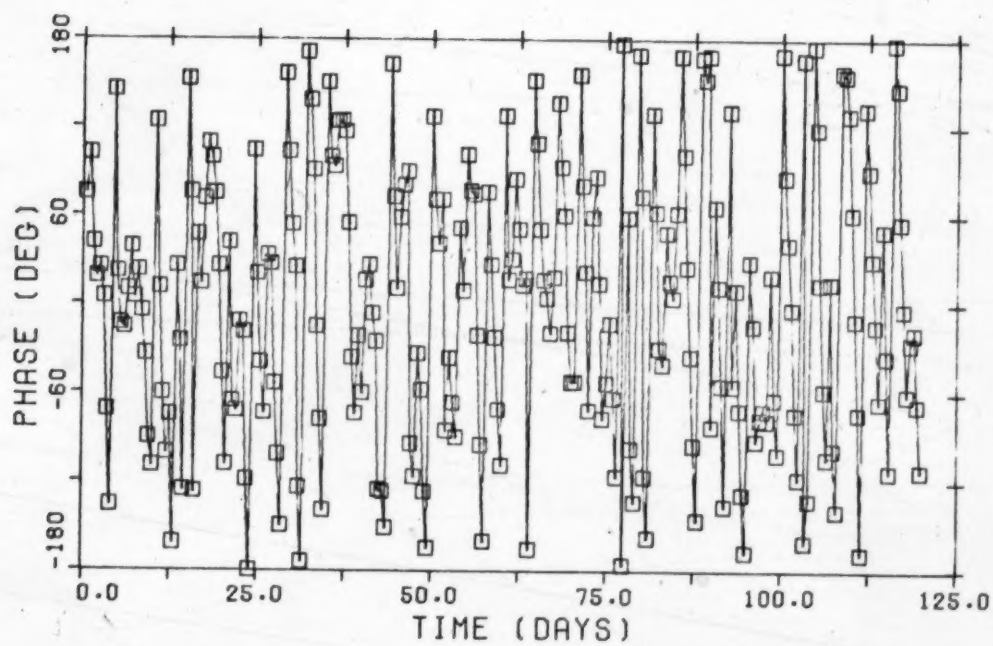
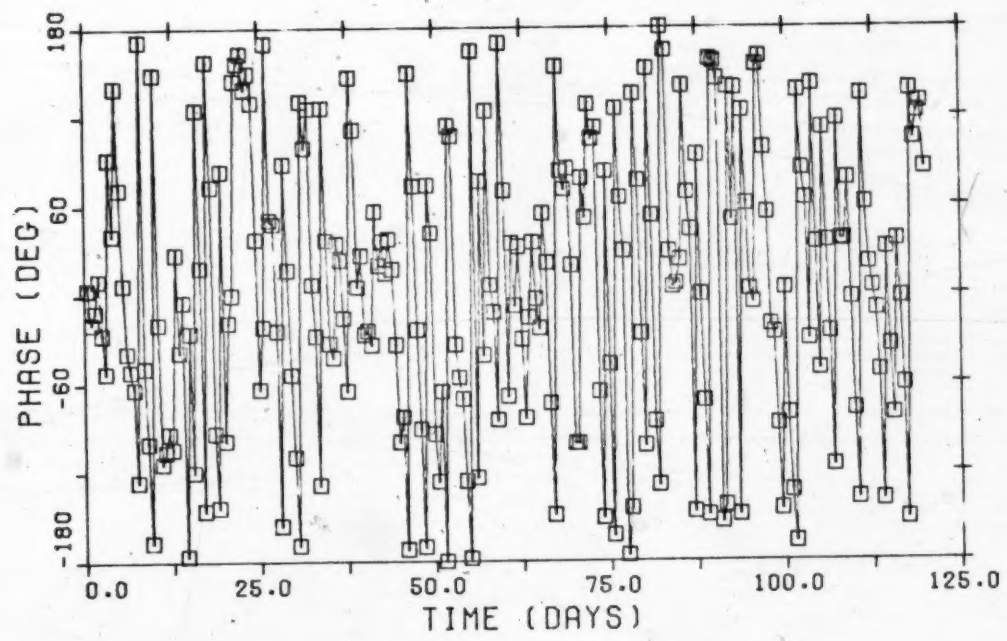


Figure E.11.

Wave Number 11



APPENDIX F

WAVE SPEED CALCULATION

Mean radius of Earth $6371\text{km} = R_0$, at 45° - distance
from axis $= R_0 \cos 45^\circ = 4520\text{km} = R$

let no. of degrees phase change per day $= \alpha$
and the wave no. $= m$

circumference $= 2\pi R = 2\pi \cdot 4520\text{km (at } 45^\circ) = 28,400\text{km}$

wavelength $= \lambda$
 $= \frac{2\pi R}{m} = \frac{28,400}{m} \text{ km}$

get distance travelled/day by

$$\begin{aligned} &= \frac{\alpha}{360^\circ} \cdot \lambda \\ &= \frac{\alpha}{360^\circ} \cdot \frac{28,400}{m} \end{aligned}$$

if $m = 2$, $\alpha = 1.029$

$$\begin{aligned} \text{then distance travelled per day} &= 40.6 \frac{\text{km}}{\text{day}} \\ &= 1.69 \frac{\text{km}}{\text{hr}} \\ &= 0.9 \text{ kt} \end{aligned}$$

APPENDIX G

LISTING AND OUTPUT OF PART 1 OF THE HEIGHT FORECAST PROGRAM

Files Needed

Number

IN	1	-Stores old trend parameters
OUT	2	-Temporary storage for new trend Parameters
IN	3	-Program parameters - see Appendix I also see Format 7 line 193
OUT	4	-Temporary storage for means of reports
IN	5	-New "k" reports to be input
OUT	7	-Temporary storage for updated AAMPL matrix
OUT	8	-Temporary storage for updated BAMPL matrix
~~OUT~~	9	-Trend values storage
OUT	10	-Deviations from trend - storage
IN	11	-Old BAMPL matrix
IN	12	-Old AAMPL matrix
IN	13	-Old means of reports
OUT	14	-Temporary storage for updated program parameters

Where

IN = needed as input
OUT = needed for output

How to Start up Program:

- 1) set first line in files 11, 12 and 13 to zero
- 2) set first line in file 1 to zero (75 columns)
- 3) set second line in file 1 to zero with a 1 in column 65
- 4) set NUMB = 0 and JI = 1 in file 3

Format of New Data

Three cards are required:

Card 1: Heights 1 to 24 in the first 72 columns and date in next 8 columns (see lines 36 and 37)

Card 2: Heights 25 to 48 in first 72 columns and any other parameter in the next 4 columns

Card 3: Heights 49 to 72 in first 72 columns and U,V (zonal and south wind).
U and V are not used in this program.

See Table G.1. for a sample output of Part 1 of the program.

Once the Program is complete, the temporary files 2, 4, 7, 8 and 14 are copied to files 1, 13, 12, 11 and 3, respectively.


```

: 1      C
: 2      C
: 3      C***** PART 1 *****
: 4      C      HEIGHT FORECAST PROGRAM
: 5      C
: 6      C
: 7      DIMENSION BUF(400)
: 8      DIMENSION DATA(72),AAMP(300,11),BAMP(300,11)
: 9      INTEGER DATE, DAY, YEAR
10     COMMON FREQ(151),A(151),B(151),AA(151)
11     COMMON /NO2/Y(300)
12     READ(5,1)K
13     C ** K=NUMBER OF NEW REPORTS TO BE READ IN
14     1 FORMAT(I3)
15     C ** CHECK STORAGE DATA BLOCK SIZE
16     READ(11,3)KLA2
17     READ(12,3)KLA1
18     3 FORMAT(I5)
19     IF(KLA2.NE.KLA1)GO TO 500
20     READ(13,4)LEN,JH,JD,JM,JY
21     C ** LEN=NUMBER OF MEANS OF REPORTS STORED
22     C ** JY,JM,JD,JH=YEAR,MONTH,DAY,HOUR OF LAST REPORT
23     4 FORMAT(I5,4I3)
24     WRITE(6,8)JY,JM,JD,JH
25     8 FORMAT(' ','DATE OF LAST DATA',4I3)
26     IF(KLA2.NE.LEN)GO TO 500
27     IF(LEN.EQ.0)GO TO 20
28     READ(13,63)(BUF(L),L=1,LEN)
29     READ(12,32)((AAMP(J,L),L=1,11),J=1,LEN)
30     READ(11,32)((BAMP(J,L),L=1,11),J=1,LEN)
31     20 ITIM=LEN+K
32     C ** READ IN NEW REPORTS
33     C IF K AMOUNT OF REPORTS NOT AVAILABLE GO TO 15
34     C ** ITIM =TOTAL NUMBER OF REPORTS (OLD +NEW)
35     DO 2 I=1,K
36     READ(5,5,END=15)(DATA(L),L=1,24),JHR,DAY,JMON,YEAR
37     5 FORMAT(24F3.0,4I2)
38     READ(5,6)(DATA(L),L=25,48),DATE
39     6 FORMAT(24F3.0,I4)
40     READ(5,7)(DATA(L),L=49,72),U,V
41     7 FORMAT(24F3.0,F4.1,F4.1)
42     C ** PRINT OUT NEW DATA
43     WRITE(6,16)YEAR,JMON,DAY,JHR
44     16 FORMAT(' ','DATE OF NEW DATA ',4(1X,I2))
45     DO 18 N=1,3
46     ML=(N-1)*24
47     MA=1+ML
48     MB=24+ML
49     18 WRITE(6,17)(DATA(L),L=MA,MB)
50     17 FORMAT(' ',24F4.0)
51     59 L=72
52     SUM=0.00

```

```

53      XL=FLOAT(L)
54      NOZRO=0
55      C ** CHECK FOR MISSING DATA
56      C      NOZRO=NUMBER OF HEIGHTS OF VALUE ZERO
57      DO 50 J=1,L
58      IF(DATA(J).EQ.0.00)NOZRO=NOZRO+1
59      50 SUM=SUM+DATA(J)
60      C ** CALCULATE MEANS
61      ANOT=SUM/XL
62      IK=I+LEN
63      BUF(IK)=ANOT
64      DO 12 J=1,L
65      C ** REMOVE MEAN FROM REPORT HEIGHTS
66      12 DATA(J)=DATA(J)-ANOT
67      DEL=5.0
68      IF(NOZRO.GT.35)GO TO 13
69      C ** TAKE FOURIER ANALYSIS OF DATA
70      CALL SPEC(DATA,L,DEL)
71      13 DO 31 J=1,11
72      IF(NOZRO.GT.10)A(J)=99.99
73      IF(NOZRO.GT.10)B(J)=99.99
74      C ** UP-DATE DATA BLOCKS
75      AAMP(IK,J)=A(J)
76      31 BAMP(IK,J)=B(J)
77      2 CONTINUE
78      C ** MA=START POINT, ITIM=END POINT
79      MA=1
80      ITI=ITIM
81      IF(ITIM.LT.300)GO TO 19
82      C ** IF NEEDED, SHIFT START AND END POINTS
83      MA=ITIM-299
84      ITI=300
85      19 WRITE(6,60)ITI
86      60 FORMAT(' ',I5)
87      JJ=0
88      DO 21 L=MA,ITIM
89      JJ=JJ+1
90      C ** RENUMBER AND STORE MEANS OF REPORTS
91      Y(JJ)=BUF(L)
92      21 CONTINUE
93      WRITE(6,61)(BUF(L),L=MA,ITIM)
94      61 FORMAT(' ',11F7.3)
95      WRITE(4,4)ITI,JHR,DAY,JMON,YEAR
96      WRITE(7,62)ITI
97      WRITE(8,62)ITI
98      WRITE(4,63)(BUF(L),L=MA,ITIM)
99      WRITE(7,32)((AAMP(J,L),L=1,11),J=MA,ITIM)
100     WRITE(8,32)((BAMP(J,L),L=1,11),J=MA,ITIM)
101     32 FORMAT(11F7.2)
102     62 FORMAT(I5)
103     63 FORMAT(11F7.3)
104     C ** GO ON TO NEXT STEP IN PROGRAM

```

```

: 105      CALL WAVE(LEN,K)
: 106      10 STOP
: 107      15 WRITE(6,700)
: 108      C ** WARNING ** K VALUE TOO LARGE
: 109      700 FORMAT(1H1,' DATA END HAS BEEN REACHED')
: 110      GO TO 2
: 111      500 WRITE(6,501)
: 112      C ** ERROR ** DATA BLOCKS OF DIFFERENT SIZES
: 113      501 FORMAT(' ','KLA2,KLA1,LEN IN CONFLICT')
: 114      STOP
: 115      END
: 116      C
: 117      C
: 118      C***** TAKE SPECTRAL ANALYSIS OF S(N) *****
: 119      C
: 120      SUBROUTINE SPEC(S,N,DEL)
: 121      DIMENSION S(300),R(150),Q(150)
: 122      COMMON FREQ(151),A(151),B(151),AA(151)
: 123      DATA TOPI/6.2831853/
: 124      K=N/2
: 125      L=N/2 + 1
: 126      1 FORMAT(I5)
: 127      2 FORMAT(' ',11F7.3)
: 128      V=FLOAT(L)
: 129      W=FLOAT(N)
: 130      DO 3 M=1,K
: 131      SUM1=0.00
: 132      SUM2=0.00
: 133      U=FLOAT(M)
: 134      C ** CALCULATE AMPLITUDE/2
: 135      DO 4 I=1,N
: 136      X=FLOAT(I)
: 137      D=TOPI*U*(X-V)/W
: 138      SUM1=SUM1+S(I)*COS(D)
: 139      4 SUM2=SUM2+S(I)*SIN(D)
: 140      A(M)=SUM1/W
: 141      3 B(M)=SUM2/W
: 142      SUM=0.00
: 143      C ** FIND MEAN OF S(N) AND STORE IN A(L)
: 144      DO 5 J=1,N
: 145      5 SUM=SUM+S(J)
: 146      A(L)=SUM/W
: 147      SUM=0.00
: 148      C ** FIND MEAN-SQUARE OF S(N) MEAN
: 149      AA(L)=A(L)*A(L)
: 150      SUM=SUM+AA(L)
: 151      R(L)=ABS(A(L))
: 152      DO 7 J=1,K
: 153      ZJ=FLOAT(J)
: 154      FREQ(J)=ZJ/(DEL*W)
: 155      R(J)=SQRT(A(J)*A(J) + B(J)*B(J))
: 156      IF(A(J).EQ.0.00)A(J)=0.0000001

```

```

: 157 C ** FIND PHASE
: 158 Q(J)=ATAN2(-B(J),A(J))*360./TOPI
: 159 C ** FIND MEAN-SQUARE
: 160 AA(J)=R(J)*R(J)*2.
: 161 IF(J.EQ.K)AA(J)=AA(J)/2.
: 162 C ** SUM=VARIANCE=TOTAL MEAN-SQUARE OF WAVES
: 163 SUM=SUM+AA(J)
: 164 IF(J.GT.40)GO TO 7
: 165 7 CONTINUE
: 166 FREQ(L)=0.000
: 167 IF(A(L).EQ.0.00)A(L)=0.0000001
: 168 Q(L)=ATAN2(-0.00,A(L))*360./TOPI
: 169 RETURN
: 170 END
: 171 C
: 172 C**** CALCULATE TREND PARAMETERS AND COEFFICIENTS
: 173 C USING LEAST SQUARE FIT TO SINE-COSINE CURVE
: 174 C (SEE APPENDIX B)
: 175 SUBROUTINE WAVE(LEN,K)
: 176 C JI= STARTING POINT OF DIAGNOSTIC DATA
: 177 C LEN=LENGTH OF BLOCKS=NUM
: 178 C KLAST= NO OF POINTS OF ORIGINAL DATA
: 179 C J=POINT WHERE TREND STARTS
: 180 C IEND=NO OF POINTS+1 THAT WERE USED TO CALCULATE
: 181 C THE STORED TREND PARAMETERS
: 182 C ILAST=NO OF POINTS TO BE USED FOR THE NEW TREND
: 183 C CALCULATION
: 184 DIMENSION Y(300),YO(400),ZZ(300)
: 185 COMMON /NO2/Y
: 186 COMMON /NO3/YO,ZZ
: 187 DATA PI/3.141593/
: 188 READ(3,7)IWAVE,RO,L,DIV,NWAVE,NUMB,RMS,JI
: 189 C ** RMS=SQUARE ROOT OF VARIANCE OF DIFFERENCES
: 190 C FROM TREND
: 191 C ** JI=START OF DATA IN DATA BLOCKS =1 ALWAYS
: 192 C ** L= NUMBER OF FORECASTS TO BE MADE
: 193 7 FORMAT(I5,F8.3,I5,F8.3,I5,I5,F7.3,I5)
: 194 Z=(2.*PI)/730.
: 195 IF(LEN.NE.NUMB)WRITE(6,99)
: 196 99 FORMAT(' ','LEN NOT = NUMB')
: 197 C ** READ IN STORED TREND PARAMETERS
: 198 READ(1,44)T,W,S,P,Q
: 199 READ(1,45)E,F,G,AN,IEND
: 200 44 FORMAT(5E15.8)
: 201 45 FORMAT(4E15.8,I5)
: 202 ILAST=IEND+K-1
: 203 KLAST=LEN+L+K
: 204 J=LEN
: 205 LEN=LEN+K
: 206 C ** LEN NOW REPRESENTS LENGTH OF ALL DATA
: 207 NUMB=LEN
: 208 WRITE(6,44)T,W,S,P,Q

```



```

: 209      WRITE(6,47)
: 210      47 FORMAT(' ',4X,'J',7X,'X',14X,'Y',13X,'COS',13X,
: 211      1'SIN')
: 212      DO 3 I=IEND,ILAST
: 213      J=J+1
: 214      X=FLOAT(I)*Z
: 215      U=COS(X)
: 216      V=SIN(X)
: 217      A=Y(J)
: 218      IF(A.EQ.0.00)GO TO 3
: 219      T=T+U
: 220      W=W+V
: 221      S=S+(U*V)
: 222      P=P+(U*U)
: 223      Q=Q+(V*V)
: 224      E=E+(A*U)
: 225      F=F+(V*A)
: 226      G=G+A
: 227      AN=AN+1
: 228      WRITE(6,46)J,X,A,U,V
: 229      46 FORMAT(' ',15,4E15.8)
: 230      3 CONTINUE
: 231      WRITE(2,44)T,W,S,P,Q
: 232      IST=ILAST+1
: 233      WRITE(2,45)E,F,G,AN,IST
: 234      R=T*S-P*W
: 235      D=((T*E-P*G)*(S*S-P*Q)-R*(S*E-P*F))
: 236      1/((S*S-P*Q)*(T*T-P*AN)-R*R)
: 237      C=((S*E-P*F)-R*D)/(S*S-P*Q)
: 238      H=(E-T*D-S*C)/P
: 239      C ** PRINT OUT TREND COEFFICIENTS
: 240      WRITE(6,4)D,H,C
: 241      4 FORMAT(' ',E13.5,' +',E13.5,' COS +',E13.5,' SIN')
: 242      ILAST=ILAST+L
: 243      CALL TREND(LEN,D,B,C,ILAST,L)
: 244      CALL DIFF(NUMB,LEN,JI,RMS)
: 245      WRITE(14,7)IWAVE,RO,L,DIV,NWAVE,NUMB,RMS,JI
: 246      STOP
: 247      END
: 248
: 249      C**** TREND FORECAST ****
: 250      C
: 251      SUBROUTINE TREND(LEN,D,B,C,KLAST,JI,IEND,ILAST,L)
: 252      DIMENSION YO(400),ZZ(300)
: 253      COMMON /NO3/YO,ZZ
: 254      DATA PI/3.141593/
: 255      Z=(2.*PI)/730.
: 256      C ** FIND START-POINT OF TREND TO FIT DATA BLOCKS
: 257      MA=ILAST-LEN-L+1
: 258      C- ** IAST=END POINT OF TREND OT MATCH DATA BLOCK
: 259      IAST=ILAST-L
: 260      C ** ILAST=END-POINT OF FORECAST PERIOD

```



```

261      WRITE(6,3)MA,IAST,ILAST
262      3 FORMAT(' ', 'TREND FROM', I6, ' TO', I6, ' EXTENDED',
263      1' TO', I6, ' POINTS - SPACED EVERY 10')
264      J=0
265      C ** GENERATE TREND FOR DIAGNOSTIC PERIOD AND
266      C FOR FORECAST PERIOD
267      DO 1 I=MA,ILAST
268      J=J+1
269      X=FLOAT(I)*Z
270      YO(J)=D+B*COS(X)+C*SIN(X)
271      1 CONTINUE
272      C ** STORE AND PRINT OUT TREND
273      WRITE(9,4)J,MA
274      4 FORMAT(2I5)
275      WRITE(9,2)(YO(I),I=1,J)
276      WRITE(6,2)(YO(I),I=1,J,10)
277      2 FORMAT(' ', 11F7.3)
278      RETURN
279      END
280      C
281      C**** CALCULATE DIFFERENCES ****
282      C
283      SUBROUTINE DIFF(NUMB,LEN,JI,RMS)
284      DIMENSION Y(300),X(400),Z(300)
285      COMMON /NO2/Y
286      COMMON /NO3/X,Z
287      DO 2 J=JI,LEN
288      IF(Y(J).EQ.0.000)GO TO 3
289      Z(J)=Y(J)-X(J)
290      GO TO 2
291      C
292      C ** SMOOTHING MISSING DATA
293      C THIS IS A SUBROUTINE IN PART 2 OF THE
294      C HEIGHT FORECAST PROGRAM
295      3 SUM=0.000
296      M=7
297      MM=M
298      C USE A 7 POINT SMOOTHER FOR MISSING DATA
299      DO 4 I=1,MM
300      IF(J.LT.(JI+3))GO TO 5
301      IF(J.GT.(LEN-3))GO TO 5
302      N=J-4+I
303      IF(Y(N).EQ.0.000)GO TO 5
304      SUM=SUM+Y(N)
305      GO TO 4
306      5 M=M-1
307      4 CONTINUE
308      IF(M.LE.0)GO TO 7
309      SUM=SUM/FLOAT(M)
310      Z(J)=SUM-X(J)
311      GO TO 2
312      7 Z(J)=0.000

```

```

: 313      C
: 314      2 CONTINUE
: 315      C ** CALCULATE MEAN AND VARIANCE
: 316          SUM1=0.000
: 317          SUM2=0.000
: 318          K=LEN-JI+1
: 319          DO 8 J=JI,LEN
: 320              SUM2=SUM2+(Z(J)*Z(J))
: 321      8 SUM1=SUM1+Z(J)
: 322          SMEAN=SUM1/K
: 323          VAR=SUM2/(K-1)
: 324          WRITE(6,12)JI,LEN
: 325      12 FORMAT(' ', 'DIFFERENCE BETWEEN 12HR MEAN AND TREND'
: 326          1, ' FROM ', I5, ' TO ', I5)
: 327          JO=LEN-NUMB+1
: 328          WRITE(10,9)NUMB
: 329      9 FORMAT(I5)
: 330      C ** PRINT OUT DIFFERENCES
: 331          WRITE(10,11)(Z(J),J=JO,LEN)
: 332          WRITE(6,11)(Z(J),J=JI,LEN)
: 333      11 FORMAT(' ', 11F7.3)
: 334          WRITE(6,10)SMEAN,VAR
: 335      C ** CALCULATE RMS
: 336          RMS=SQRT(VAR)
: 337      10 FORMAT(' ', 6X, 'MEAN=', F10.3, 6X, 'VARIANCE=', F10.3)
: 338          RETURN
: 339          END
:

```


APPENDIX H

LISTING OF PART 2 OF THE PROGRAM

Files Needed

	Number	
IN	3	-Program parameters - see Appendix I also see Format 6 line 37
IN	9	-Trend values storage (from Part 1 of the program)
IN	10	-Deviations from trend - storage (from Part 1 of the program)
IN	11	-Updated BAMPL matrix (from Part 1 of the program)
IN	12	-Updated AAMPL matrix (from Part 1 of the program)
OUT	14	-Storage for forecasts of the AAMPL matrix
OUT	15	-Storage for forecasts of the BAMPL matrix
OUT	16	-Storage for forecasts of the deviations from the trend
OUT	13	-Storage for forecasts of heights

Where

IN = needed as input
OUT = needed for output


```

: 1 C**** PART 2 ****
: 2 C
: 3 C
: 4 DIMENSION BUF(400)
: 5 COMMON /NO4/Z(400),AAMP(400,11),BAMP(400,11)
: 6 COMMON FREQ(151),R(151),Q(151),AA(151)
: 7 C ** CHECK SIZE OF STORED DATA BLOCKS
: 8 READ(11,1)NUMB
: 9 READ(10,1)NUMB1
: 10 READ(12,1)NUMB2
: 11 1 FORMAT(I5)
: 12 IF(NUMB1.NE.NUMB2)GO TO 900
: 13 IF(NUMB1.NE.NUMB)GO TO 900
: 14 GO TO 2
: 15 900 WRITE(6,100)NUMB,NUMB1,NUMB2
: 16 100 FORMAT(' ','DATA IN BLOCKS OF DIFFERENT SIZE',3I5)
: 17 STOP
: 18 C
: 19 C
: 20 C
: 21 C ** READ IN DIFFERENCES(MEAN-TREND)
: 22 2 READ(10,3)(Z(J),J=1,NUMB)
: 23 3 FORMAT(' ',11F7.3)
: 24 C ** READ IN STORED AMPLITUDES/2
: 25 READ(12,4)((AAMP(J,L),L=1,11),J=1,NUMB)
: 26 READ(11,4)((BAMP(J,L),L=1,11),J=1,NUMB)
: 27 4 FORMAT(11F7.2)
: 28 C ** READ IN PROGRAM PARAMETERS
: 29 C IWAVE=NUMBER OF SORTED STRONG WAVES TO BE PRINTED
: 30 C PRINT=OPTION INDICATOR
: 31 C L=NUMBER OF FORECASTS TO BE MADE
: 32 C DIV=JWAVE IN REAL FORMAT
: 33 C NWAVE=MAXIMUM NUMBER OF TIME WAVES IN FORECAST
: 34 C NUM=NUMB=LENGTH OF DIAGNOSTIC DATA BLOCKS
: 35 C RMS,JI=PARAMETERS USED IN PART 1
: 36 READ(3,6)IWAVE,PRINT,L,DIV,NWAVE,NUM,RMS,JI
: 37 6 FORMAT(I5,F8.3,I5,F8.3,I5,I5,F7.3,I5)
: 38 WRITE(6,17)NUMB
: 39 17 FORMAT(' ','NUMBER OF DATA POINTS =',I5)
: 40 C
: 41 C
: 42 C
: 43 C
: 44 KLAST=NUMB+L
: 45 AMPLO=0.15
: 46 C ** AMPLO=MINIMUM AMPLITUDE ALLOWED FOR A FORECAST WAVE
: 47 DEL=12.0
: 48 C ** DEL=NUMBER OF HOURS BETWEEN REPORTS
: 49 C ** START TO OPERATE ON DIFFERENCES
: 50 WRITE(6,7)
: 51 7 FORMAT(' ','SPEC FROM MEAN-TREND DIFFERENCES')
: 52 CALL SPEC(Z,NUMB,DEL)
: 53 CALL SPOUT(NUMB,RO,JH,SUM,PRINT,RMAX,JJ)

```



```

54      IF(ABS(PRINT).GT.3.5)GO TO 5
55      CALL SPCSM(JJ,SUM,PRINT)
56      5 CALL SORT(IWAVE,JH,SUM,PRINT)
57      CALL FCST(NWAVE,RO,L,DEL,JI,NUMB,BUF,AMPLO,PRINT)
58      DO 18 I=1,KLAST
59      18 Z(I)=BUF(I)
60      C
61      C
62      C ** START TO OPERATE ON AMPLITUDES
63      C   IA=WAVE NUMBER COUNTER
64      C ** FIRST AAMPL
65      IA=1
66      JWAVE=DIV/1
67      DATMS=99.99
68      16 WRITE(6,11)IA
69      11 FORMAT(' ','SPEC FROM COS AMPLITUDES',8X,'WAVE NO',I5)
70      DO 10 I=1,NUMB
71      10 BUF(I)=AAMP(I,IA)
72      CALL SM7PT(BUF,NUMB,DATMS)
73      CALL SPEC(BUF,NUMB,DEL)
74      CALL SPOUT(NUMB,RO,JH,SUM,PRINT,RMAX,JJ)
75      IF(ABS(PRINT).GT.3.5)GO TO 8
76      CALL SPCSM(JJ,SUM,PRINT)
77      8 CALL SORT(IWAVE,JH,SUM,PRINT)
78      CALL FCST(NWAVE,RO,L,DEL,JI,NUMB,BUF,AMPLO,PRINT)
79      DO 19 I=1,KLAST
80      19 AAMP(I,IA)=BUF(I)
81      C
82      C
83      C
84      C ** NEXT BAMPL
85      WRITE(6,14)IA
86      14 FORMAT(' ','SPEC FROM SIN AMPLITUDES',8X,'WAVE NO',I5)
87      DO 13 I=1,NUMB
88      13 BUF(I)=BAMP(I,IA)
89      CALL SM7PT(BUF,NUMB,DATMS)
90      CALL SPEC(BUF,NUMB,DEL)
91      CALL SPOUT(NUMB,RO,JH,SUM,PRINT,RMAX,JJ)
92      IF(ABS(PRINT).GT.3.5)GO TO 9
93      CALL SPCSM(JJ,SUM,PRINT)
94      9 CALL SORT(IWAVE,JH,SUM,PRINT)
95      CALL FCST(NWAVE,RO,L,DEL,JI,NUMB,BUF,AMPLO,PRINT)
96      DO 20 I=1,KLAST
97      20 BAMP(I,IA)=BUF(I)
98      C ** CHECK TO SEE IF MAXIMUM WAVE NUMBER REACHED
99      IA=IA+1
100     IF(IA.LE.JWAVE)GO TO 16
101     25 FORMAT(I5)
102     C ** STORE NEW DATA BLOCKS
103     WRITE(14,25)KLAST
104     WRITE(15,25)KLAST
105     WRITE(16,25)KLAST
106     DO 24 I=1,KLAST

```

```

: 107      WRITE(14,23)(AAMP(I,J),J=1,JWAVE)
: 108      24 WRITE(15,23)(BAMP(I,J),J=1,JWAVE)
: 109      WRITE(16,23)(Z(J),J=1,KLAST)
: 110      C ** CHECK TO SEE IF WANT AAMPL PRINTED
: 111      IF(ABS(PRINT).LT.9.5)GO TO 26
: 112      DO 21 I=NUMB,KLAST
: 113      WRITE(6,23)(AAMP(I,J),J=1,JWAVE)
: 114      23 FORMAT(' ',11F7.3)
: 115      21 CONTINUE
: 116      26 CONTINUE
: 117      C ** FORECAST REPORTS
: 118      CALL FCDAT(JWAVE,KLAST,NUMB,PRINT)
: 119      C
: 120      C
: 121      STOP
: 122      END
: 123      C
: 124      C
: 125      C***** 7 POINT SMOOTHER *****
: 126      C      USED TO ESTIMATE MISSING DATA
: 127      C
: 128      SUBROUTINE SM7PT(BUF,NUMB,DATMS)
: 129      C ** NUMB= SIZE OF BUF (LESS THAN 400 ELEMENTS)
: 130      C ** DATMS=VALUE ASSIGNED TO MISSING DATA
: 131      DIMENSION BUF(400)
: 132      DO 1 J=1,NUMB
: 133      IF(ABS(BUF(J)-DATMS).GT.0.01)GO TO 1
: 134      SUM=0.00
: 135      M=7
: 136      DO 2 I=1,7
: 137      N=J-4+I
: 138      IF((N.LT.1).OR.(N.GT.NUMB))GO TO 3
: 139      IF(ABS(BUF(J)-DATMS).LT.0.01)GO TO 3
: 140      SUM=SUM+BUF(N)
: 141      GO TO 2
: 142      3 M=M-1
: 143      2 CONTINUE
: 144      IF(M.LE.0)GO TO 4
: 145      BUF(J)=SUM/FLOAT(M)
: 146      C ** SINCE THE MISSING DATA IS REPLACED WHEN
: 147      C      DETECTED THEN IT IS USED FOR THE NEXT
: 148      C      REPORT IF IT IS ALSO MISSING
: 149      GO TO 1
: 150      4 BUF(J)=0.00
: 151      1 CONTINUE
: 152      RETURN
: 153      END
: 154      C
: 155      C
: 156      C***** PRINT OUT DATA FROM SPECTRAL ANALYSIS ****
: 157      C
: 158      SUBROUTINE SPOUT(NUMB,RO,JH,SUM,PRINT,RMAX,JJ)
: 159      COMMON FREQ(151),R(151),Q(151),AA(151)

```

```

: 160 C ** NUMB=SIZE OF DIAGNOSTIC DATA SETS
: 161 C RO=MEAN OF REPORT
: 162 C JH=MAXIMUM NUMBER OF SPECTRAL FREQUENCIES
: 163 C RMAX=SUM OF THE SPECTRAL AMPLITUDES/2
: 164 C SUM=SUM OF THE MEAN SQUARES AA(I)
: 165 C Q=PHASE
: 166 C R=AMPLITUDE/2
: 167 C JJ=NUMB/2 +1
: 168 C JH=JJ-1
: 169 C SUM=0.00
: 170 C RMAX=0.000
: 171 C DO 18 I=1,JH
: 172 C RMAX=RMAX+R(I)
: 173 18 SUM=SUM+AA(I)
: 174 C IF(JH.GT.40)JH=40
: 175 C IF(PRINT.LT.0.00)GO TO 5
: 176 C WRITE(6,16)
: 177 16 FORMAT(' ',10X,'FREQ',10X,'AMPL',10X,'PHASE',8X,
: 178 1 'MEAN SQR',8X,'POWER')
: 179 C WRITE(6,9)FREQ(JJ),R(JJ),Q(JJ),AA(JJ)
: 180 C DO 8 I=1,JH
: 181 C POWER=AA(I)/SUM
: 182 8 WRITE(6,9)FREQ(I),R(I),Q(I),AA(I),POWER
: 183 9 FORMAT(' ',5F15.5)
: 184 5 CONTINUE
: 185 C RO=R(JJ)
: 186 C IF((180.00-ABS(Q(JJ))).LT.(0.10))RO=-RO
: 187 C WRITE(6,2)SUM,RMAX
: 188 2 FORMAT(' ', 'VARIANCE = ',F7.3,5X,'MAXIMUM AMPLITUDE'
: 189 1, '/2 = ',F7.3)
: 190 C RETURN
: 191 C END
: 192 C
: 193 C***** TAKE SPECTRAL ANALYSIS OF S(N) *****
: 194 C
: 195 C SUBROUTINE SPEC(S,N,DEL)
: 196 C DIMENSION S(400),A(150),B(150)
: 197 C COMMON FREQ(151),R(151),Q(151),AA(151)
: 198 C ** A(I)=COSINE COMPONENT OF WAVE NUMBER I
: 199 C B(I)=SINE COMPONENT OF WAVE NUMBER I
: 200 C N=NUMBER OF ELEMENTS IN VECTOR S (N LESS THAN 400)
: 201 C ** NOTE ** SQUARE OF MEAN OF S(N) STORED IN AA(L)
: 202 C DATA TOPI/6.2831853/
: 203 C K=N/2
: 204 C L=N/2 + 1
: 205 1 FORMAT(I5)
: 206 2 FORMAT(' ',11F7.3)
: 207 C V=FLOAT(L)
: 208 C W=FLOAT(N)
: 209 C DO 3 M=1,K
: 210 C SUM1=0.00
: 211 C SUM2=0.00
: 212 C U=FLOAT(M)

```

```

: 213      DO 4 I=1,N
: 214      X=FLOAT(I)
: 215      D=TOPI*U*(X-V)/W
: 216      SUM1=SUM1+S(I)*COS(D)
: 217      4 SUM2=SUM2+S(I)*SIN(D)
: 218      C ** CALCULATE SINE AND COSINE COMPONENTS
: 219      A(M)=SUM1/W
: 220      3 B(M)=SUM2/W
: 221      SUM=0.00
: 222      DO 5 J=1,N
: 223      5 SUM=SUM+S(J)
: 224      A(L)=SUM/W
: 225      SUM=0.00
: 226      AA(L)=A(L)*A(L)
: 227      SUM=SUM+AA(L)
: 228      R(L)=ABS(A(L))
: 229      DO 7 J=1,K
: 230      C ** CALCULATE THE FREQUENCIES IN CYCLES PER HOUR
: 231      ZJ=FLOAT(J)
: 232      FREQ(J)=ZJ/(DEL*W)
: 233      R(J)=SQRT(A(J)*A(J) + B(J)*B(J))
: 234      IF(A(J).EQ.0.00)A(J)=0.0000001
: 235      C ** CALCULATE PHASE
: 236      Q(J)=ATAN2(-B(J),A(J))*360./TOPI
: 237      C ** CALCULATE MEAN SQUARE
: 238      AA(J)=R(J)*R(J)*2.
: 239      IF(J.EQ.K)AA(J)=AA(J)/2.
: 240      SUM=SUM+AA(J)
: 241      IF(J.GT.40)GO TO 7
: 242      7 CONTINUE
: 243      FREQ(L)=0.00
: 244      IF(A(L).EQ.0.000)A(L)=0.00000001
: 245      C ** CALCULATE THE PHASE OF THE MEAN OF S(N)
: 246      C IF Q=+,-180. THEN MEAN=-MEAN
: 247      C IF Q=0. THEN MEAN HAS NO SIGN CHANGE
: 248      Q(L)=ATAN2(-0.00,A(L))*360./TOPI
: 249      RETURN
: 250      END
: 251      C
: 252      C***** LIST WAVES ACCORDING TO AMPLITUDE MAGNITUDE
: 253      C LARGEST AMPLITUDE WAVE LISTED FIRST
: 254      C SMALLEST AMPLITUDE WAVE LISTED LAST
: 255      SUBROUTINE SORT(IWAVE,L,SUM,PRINT)
: 256      C IWAVE=NO OF FREQUENCIES
: 257      C ** L=NUMBER OF FORECASTS TO BE MADE
: 258      C SUM=TOTAL OF MEAN SQUARES OF WAVES
: 259      C PRINT=PROGRAM PARAMETER
: 260      C ITOP=ROW INDICATOR
: 261      COMMON FREQ(151),AMPL(151),PHASE(151),AA(151)
: 262      ITOP=1
: 263      C ** STORE FIRST FREQUENCY
: 264      4 BUF=FREQ(ITOP)
: 265      BUA=AMPL(ITOP)

```



```

: 266      BUP=PHASE(ITOP)
: 267      BUPR=AA(ITOP)
: 268      ITOP=ITOP+1
: 269      C  ** SEARCH THROUGH ROWS.
: 270      DO 1 J=ITOP,L
: 271      IF(BUA.GE.AMPL(J))GO TO 1
: 272      C  ** IF AMPLITUDE/2 LARGER THAN STORED WAVE THEN STORE
: 273      C  THIS WAVE INSTEAD AND MOVE OLD STORED WAVE TO THIS
: 274      C  ROW
: 275      STORF=FREQ(J)
: 276      STORA=AMPL(J)
: 277      STORP=PHASE(J)
: 278      STOPR=AA(J)
: 279      FREQ(J)=BUP
: 280      AMPL(J)=BUA
: 281      PHASE(J)=BUP
: 282      AA(J)=BUPR
: 283      BUP=STORF
: 284      BUA=STORA
: 285      BUP=STORP
: 286      BUPR=STOPR
: 287      1 CONTINUE
: 288      K=ITOP-1
: 289      C  ** SHIFT STORED WAVE TO PREVIOUS ROW
: 290      FREQ(K)=BUP
: 291      AMPL(K)=BUA
: 292      PHASE(K)=BUP
: 293      AA(K)=BUPR
: 294      IF(K.EQ.IWAVE)GO TO 6
: 295      IF(K.GT.L)GO TO 5
: 296      GO TO 4
: 297      5 WRITE(6,7)K
: 298      7 FORMAT(' ',I3,' THERE APPEARS TO BE SOME ERROR',
: 299      1' ITEST=',I5)
: 300      RETURN
: 301      6 CONTINUE
: 302      C  ** CHECK TO SEE IF WANT STRONGEST WAVES PRINTED OUT
: 303      C  IF PRINT GREATER THAN 0.5 THEN THEY ARE PRINTED OUT
: 304      IF(ABS(PRINT).LT.0.5)GO TO 3
: 305      WRITE(6,9)IWAVE
: 306      9 FORMAT(' ',I5,' THE ',I5,' STRONGEST WAVES')
: 307      WRITE(6,13)
: 308      13 FORMAT(' ',FREQ',3X',AMPL',4X',PHASE',6X',RMS')
: 309      3 CONTINUE
: 310      TOT=0.00
: 311      C  ** ADD UP MEAN SQUARES OF THE 6 STRONGEST WAVES
: 312      DO 8 J=1,IWAVE
: 313      IF(J.GT.6)GO TO 12
: 314      TOT=TOT+AA(J)
: 315      12 CONTINUE
: 316      IF(ABS(PRINT).LT.0.5)GO TO 8
: 317      WRITE(6,2)FREQ(J),AMPL(J),PHASE(J),AA(J)
: 318      2 FORMAT(' ',F7.5,F8.3,2F9.3)

```



```

: 319      8 CONTINUE
: 320      TOTAL=TOT/SUM
: 321      WRITE(6,10)TOTAL
: 322      10 FORMAT(' ', 'FOR FIRST 6 WAVES VARIANCE EXPLAINED'
: 323      1,F7.3)
: 324      RETURN
: 325      END
: 326      C
: 327      C***** FORECAST TIME WAVES IN AAMPL, BAMPL,
: 328      C      AND DIFFERENCES *****
: 329      C
: 330      SUBROUTINE FCST(NWAVE,RO,L,DEL,JI,NUMB,VALUE,
: 331      1AMPLO,PRINT)
: 332      DIMENSION VALUE(400),A(151)
: 333      COMMON FREQ(151),AMPL(151),PHASE(151),AA(151)
: 334      DATA PI/3.141593/
: 335      Q=2.*PI/360.
: 336      X=2.*PI*DEL
: 337      KLAST=NUMB+L
: 338      K=0
: 339      C ** BY-PASS THIS LOOP IF CLIMATOLOGY FORECAST WANTED
: 340      IF(ABS(ABS(PRINT)-5.5).LT.0.1)GO TO 8
: 341      DO 7 I=1,NWAVE
: 342      A(I)=2.*AMPL(I)
: 343      K=K+1
: 344      C ** CHECK TO SEE IF THE AMPLITUDE IS LARGE ENOUGH
: 345      C      TO BE USE : IF AMPL LESS THAN AMPLO THEN NOT USED
: 346      IF(AMPL(I).LT.AMPLO)GO TO 8
: 347      7 CONTINUE
: 348      8 WRITE(6,10)K
: 349      10 FORMAT(' ', ' THE FIRST ',I5,' WAVES WILL BE USED')
: 350      JORG=1+(NUMB/2)
: 351      C ** JORG=ORIGIN
: 352      DO 3 J=JI,KLAST
: 353      SUM=RO
: 354      C ** CHECK FOR CLIMAT FORECAST
: 355      IF(ABS(ABS(PRINT)-5.5).LT.0.1)GO TO 6
: 356      JN=J-JORG
: 357      T=FLOAT(JN)
: 358      C ** ADD FORECAST WAVES TO MEAN OF AMPLITUDE
: 359      DO 4 I=1,K
: 360      SUM=SUM+A(I)*COS(X*FREQ(I)*T+Q*PHASE(I))
: 361      4 CONTINUE
: 362      6 VALUE(J)=SUM
: 363      3 CONTINUE
: 364      RETURN
: 365      END
: 366      C
: 367      C***** FORECAST REPORTS *****
: 368      C
: 369      SUBROUTINE FCDAT(JWAVE,KLAST,NUMB,PRINT)
: 370      DIMENSION YO(400),RO(400),S(72)
: 371      COMMON /NO4/Z(400),AAMP(400,11),BAMP(400,11)

```

```

: 372      DATA TOPI/6.2831853/,F1/1.3888889E-02/
: 373      C ** F1=FUNDAMENTAL FREQUENCY
: 374      READ(9,1)KLAS1,MA
: 375      1 FORMAT(2I5)
: 376      IF(KLAST.EQ.KLAS1)GO TO 2
: 377      WRITE(6,3)
: 378      3 FORMAT(' ','TREND AND KLAST DO NOT MATCH')
: 379      STOP
: 380      C
: 381      C ** GET TREND FROM STORAGE
: 382      2 READ(9,4)(YO(I),I=1,KLAST)
: 383      4 FORMAT(' ',11F7.3)
: 384      DO 5 I=NUMB,KLAST
: 385      C ** ADD DIFFERENCES TO TREND TO GET FORECAST
: 386      C      MEAN OF THE REPORT
: 387      RO(I)=YO(I)+Z(I)
: 388      5 CONTINUE
: 389      IPRINT=IFIX(PRINT)
: 390      WRITE(13,1)KLAST,IPRINT
: 391      DO 6 I=NUMB,KLAST
: 392      C ** THIS WILL PRINT OUT FORECAST MEANS OF THE REPORT
: 393      C      IF /PRINT/ GREATER THAN 7.5
: 394      IF(ABS(PRINT).LT.7.5)GO TO 12
: 395      WRITE(6,10)RO(I)
: 396      10 FORMAT(' ','RO(I)=',F7.3)
: 397      12 CONTINUE
: 398      C ** USE FORECASTS OF AAMPL AND BAMPL TO
: 399      C      FORECAST REPORTS
: 400      DO 7 J=1,72
: 401      SUM=RO(I)
: 402      X=FLOAT(J-37)*F1*TOPI
: 403      DO 8 M=1,JWAVE
: 404      D=FLOAT(M)*X
: 405      C=COS(D)
: 406      SI=SIN(D)
: 407      SUM=SUM+2.*AAMP(I,M)*C+2.*BAMP(I,M)*SI
: 408      8 CONTINUE
: 409      S(J)=SUM
: 410      7 CONTINUE
: 411      C ** STORE FORECAST REPORT
: 412      WRITE(13,9)(S(J),J=1,72)
: 413      9 FORMAT(' ',3(/24F4.0))
: 414      6 CONTINUE
: 415      RETURN
: 416      END
: 417      C
: 418      C***** SMOOTHING SPECTRUM *****
: 419      C      (SEE CHAPTER 3 )
: 420      SUBROUTINE SPCSM(JJ,SUM,PRINT)
: 421      DIMENSION SMPH(151),SMAA(151),SMFR(151),A(151)
: 422      DIMENSION OLDR(151),ASQ(151),BSQ(151),AABSA(151)
: 422.1      DIMENSION B(151),BABSB(151)
: 423      COMMON FREQ(151),R(151),Q(151),AA(151)

```

```

: 424      DATA TOPI/6.2831853/
: 425      T=TOPI/360.
: 426      JH=JJ-1
: 427      JP=JJ-2
: 428      C  ** PREPARE DATA FOR USE IN SMOOTHING OPTIONS
: 429      DO 1 J=1,JH
: 430      PHASE=Q(J)*T
: 431      A(J)=R(J)*COS(PHASE)
: 432      B(J)=-R(J)*SIN(PHASE)
: 433      ASQ(J)=A(J)*A(J)
: 434      BSQ(J)=B(J)*B(J)
: 435      AABSA(J)=A(J)*ABS(A(J))
: 436      BABSB(J)=B(J)*ABS(B(J))
: 437      1 CONTINUE
: 438      C
: 439      C
: 440      C  ** CHOOSE OPTION
: 441      IF(ABS(ABS(PRINT)-3.0).LT.0.1)GO TO 300
: 442      IF(ABS(ABS(PRINT)-2.0).LT.0.1)GO TO 200
: 443      IF(ABS(ABS(PRINT)-1.0).LT.0.1)GO TO 100
: 444      WRITE(6,2)
: 445      2 FORMAT(' ','***NO SMOOTHING OPTION USED ***')
: 446      RETURN
: 447      C
: 448      C
: 449      C
: 450      300 WRITE(6,301)
: 451      301 FORMAT(' ',' SMOOTHING OPTION NUMBER 3 USED')
: 452      AR=(AABSA(1)+AABSA(2))/2.
: 453      BR=(BABSB(1)+BABSB(2))/2.
: 454      SMPH(1)=ATAN2(-BR,AR)/T
: 455      SMAA(1)=ABS(AR)+ABS(BR)
: 456      SMFR(1)=(FREQ(1)*AA(1)+FREQ(2)*AA(2))/(AA(1)+AA(2))
: 457      DO 302 J=2,JP
: 458      AR=(AABSA(J-1)+AABSA(J)+AABSA(J+1))/3.
: 459      BR=(BABSB(J-1)+BABSB(J)+BABSB(J+1))/3.
: 460      SMPH(J)=ATAN2(-BR,AR)/T
: 461      SMAA(J)=(ABS(AR)+ABS(BR))*2./3.
: 462      SMFR(J)=(FREQ(J-1)*AA(J-1)+FREQ(J)*AA(J)+FREQ(J+1)*
: 463      1AA(J+1))/(AA(J-1)+AA(J)+AA(J+1))
: 464      302 CONTINUE
: 465      SMAA(JH)=AA(JH)
: 466      SMFR(JH)=FREQ(JH)
: 467      SMPH(JH)=Q(JH)
: 468      GO TO 500
: 469      C
: 470      C
: 471      C
: 472      200 WRITE(6,201)
: 473      201 FORMAT(' ',' SMOOTHING OPTION NUMBER 2 USED')
: 474      AR=(A(1)+A(2))/2.
: 475      BR=(B(1)+B(2))/2.
: 476      SMPH(1)=ATAN2(-BR,AR)/T

```

```

: 477      SMAA(1)=AA(1)+AA(2)
: 478      SMFR(1)=(FREQ(1)*AA(1)+FREQ(2)*AA(2))/SMAA(1)
: 479      SMAA(1)=SMAA(1)/2.
: 480      DO 202 J=2,JP
: 481      AR=(A(J-1)+A(J)+A(J+1))/3.
: 482      BR=(B(J-1)+B(J)+B(J+1))/3.
: 483      SMPH(J)=ATAN2(-BR,AR)/T
: 484      SMAA(J)=AA(J-1)+AA(J)+AA(J+1)
: 485      SMFR(J)=(FREQ(J-1)*AA(J-1)+FREQ(J)*AA(J)+FREQ(J+1)*
: 486      2AA(J+1))/SMAA(J)
: 487      SMAA(J)=SMAA(J)/3.
: 488      202 CONTINUE
: 489      SMAA(JH)=AA(JH)
: 490      SMFR(JH)=FREQ(JH)
: 491      SMPH(JH)=Q(JH)
: 492      GO TO 500
: 493      C
: 494      C
: 495      C
: 496      100 WRITE(6,101)
: 497      101 FORMAT(' ', 'SMOOTHING OPTION NUMBER 1 USED')
: 498      AR=(A(1)+A(2))/2.
: 499      BR=(B(1)+B(2))/2.
: 500      SMAA(1)=(AR*AR+BR*BR)*2.
: 501      SMFR(1)=(FREQ(1)*AA(1)+FREQ(2)*AA(2))/(AA(1)+AA(2))
: 502      SMPH(1)=ATAN2(-BR,AR)/T
: 503      DO 102 J=2,JP
: 504      AR=(A(J-1)+A(J)+A(J+1))/3.
: 505      BR=(B(J-1)+B(J)+B(J+1))/3.
: 506      SMPH(J)=ATAN2(-BR,AR)/T
: 507      SMAA(J)=(AR*AR+BR*BR)*2.
: 508      SMFR(J)=(FREQ(J-1)*AA(J-1)+FREQ(J)*AA(J)+FREQ(J+1)*
: 509      3AA(J+1))/(AA(J-1)+AA(J)+AA(J+1))
: 510      102 CONTINUE
: 511      SMAA(JH)=AA(JH)
: 512      SMAA(JH)=AA(JH)
: 513      SMFR(JH)=FREQ(JH)
: 514      SMPH(JH)=Q(JH)
: 515      C
: 516      C
: 517      C
: 518      500 CONTINUE
: 519      SRMAX=0.00
: 520      C ** MOVE SMOOTHED DATA TO COMMON BLOCK ELEMENTS
: 521      DO 501 I=1,JH
: 522      AA(I)=SMAA(I)
: 523      OLDR(I)=SQRT(SMAA(I)/2.)
: 524      SRMAX=SRMAX+AA(I)
: 525      Q(I)=SMPH(I)
: 526      FREQ(I)=SMFR(I)
: 527      501 CONTINUE
: 528      WRITE(6,502)
: 529      502 FORMAT(' ',10X,'FREQ',10X,'AMP',12X,'OLD R',8X,

```



```
: 530      4'PHASE',8X,'SMOOTH MEAN SQ')
: 531      IF(SRMAX.LT.0.0001)SRMAX=0.0001
: 532      C ** SMOOTHING FINISHED--- DO VARIANCE ADJUST
: 533      DO 503 I=1,JH
: 534      AA(I)=SUM*AA(I)/SRMAX
: 535      R(I)=SQRT(AA(I)/2.)
: 536      IF(I.GT.40)GO TO 503
: 537      WRITE(6,504)FREQ(I),R(I),OLDR(I),Q(I),AA(I)
: 538      504 FORMAT(' ',5F15.5)
: 539      503 CONTINUE
: 540      WRITE(6,505)SRMAX
: 541      505 FORMAT(' ', 'TOTAL SMOOTH AMPLITUDE SQUARED * 2 =',
: 541.5      1F7.3)
: 542      RETURN
: 543      END
:
```


APPENDIX I

PROGRAM PARAMETERS

IWAVE = number of strong waves that are to be listed.
These waves have been sorted according to the
magnitude of the amplitude.

PRINT = parameter that determines smoothing option to
be used (see below description).

L = number of forecasts to be made.

DIV(=JWAVE) = number of space-waves used to forecast
heights.

NWAVE = number of time-waves used to forecast amplitudes
for space-waves.

NUM = NUMB = number of elements in the diagnostic data
sets.

RMS = $(\text{Variance})^{1/2}$. The variance of differences from the
trend

JI = starting point of diagnostic data sets

Values for PRINT Parameter

If print is negative, then the unsmoothed spectrum
is not listed.

Absolute Value of PRINT

LT 0.5: no smoothing option used plus sorted strong
waves not printed out.

= 1.0 $\pm$ 0.1: smoothing option No. 1 used.

= 2.0 $\pm$ 0.1: smoothing option No. 2 used.

= 3.0 $\pm$ 0.1: smoothing option No. 3 used.

GT 3.5: no smoothing option chosen, therefore, bypass
smoothing subroutine SPCSM

= 4.0: persistence forecast made (see verification
program listing in Appendix I)

= 5.5: climatology forecast made
note space-wave pattern is constant but
means still adjusted for trend

= 6.0: value that can be used when verification
program also used.

GE 7.5: print out forecast means

GT 9.5: print out estimated AAMPL for forecast period

LT = less than

GT = greater than

GE = greater than or equal to.

APPENDIX J

LISTING OF VERIFICATION PROGRAM

Files Needed for Input

Number

- 13 -Forecast height reports from Part 2 of the program.
- 5 -Actual height reports.

Note: Persistence forecasts are generated by lines 42 to 47.

```

1      C
2      C
3      C *** VERIFICATION PROGRAM ***
4      C*****
5      C
6      C
7      DIMENSION S(72),Y(72),D(72),A(72),R(60),RMSEE(60)
8      INTEGER HOV(60,72),FHOV(60,72)
9      READ(13,1)KLAST,IPRINT
10     1  FORMAT(2I5)
11     TOTAL=28.0
12     DO 2 I=1,60
13     NOZO=0
14     IO=I-1
15     TIME=FLOAT(IO)/2.
16     WRITE(6,78)IO,TIME
17     78  FORMAT('0','FORECAST',I5,'=',5X,'TO+',F5.1,' DAYS')
18     READ(13,9)(S(J),J=1,72)
19     9   FORMAT(' ',3(24F4.0))
20     READ(5,8)(Y(J),J=1,72)
21     8   FORMAT(2(24F3.0,8X/),24F3.0)
22     C ** SET UP HOVMOLLER DIAGRAMS
23     C   HOV= ACTUAL HEIGHTS
24     C   FHOV=FORECAST HEIGHTS
25     DO 15 L=1,72
26     HOV(I,L)=IFIX(Y(L))
27     FHOV(I,L)=IFIX(S(L))
28     IF(Y(L).EQ.0.00)NOZO=NOZO+1
29     IF(I.GT.1)GO TO 15
30     A(L)=Y(L)
31     15  CONTINUE
32     C ** CHECK FOR MISSING DATA
33     IF(NOZO.LT.35)GO TO 16
34     WRITE(6,17)NOZO
35     17  FORMAT(' ', ' DATA MISSING NO ZEROS=',I5)
36     R(I)=99.99
37     RMSEE(I)=-9.99
38     TOTAL=TOTAL-1.
39     GO TO 2
40     C
41     C
42     C ** CHECK TO SEE IF PERSISTANCE FORECAST WANTED
43     16  IF(IPRINT.NE.4)GO TO 21
44     DO 21 J=1,72
45     S(J)=A(J)
46     FHOV(I,J)=IFIX(S(J))
47     21  CONTINUE
48     C ** PRINT HEIGHTS
49     WRITE(6,19)
50     19  FORMAT(' ', ' FORECAST REPORT = S(L)')
51     WRITE(6,77)(S(J),J=1,72)
52     77  FORMAT(' ',3(24F4.0/,1X))

```

```

53      WRITE(6,18)
54      18 FORMAT(' ', ' ACTUAL REPORT = Y(L)')
55      WRITE(6,77)(Y(J),J=1,72)
56      C
57      C **** CALCULATE STATISTICS FOR THIS FORECAST
58      C      AND ACTUAL HEIGHT DATA AT THIS TIME
59      COF=99.
60      SO=0.00
61      SMAG=0.00
62      YMAG=0.00
63      SDOTY=0.00
64      SUM2=0.00
65      SUM1=0.00
66      SUM=0.00
67      DO 3 K=1,72
68      D(K)=S(K)-Y(K)
69      SUM=SUM+ABS(D(K))
70      SUM1=SUM1+D(K)*D(K)
71      SUM2=SUM2+D(K)
72      SO=S(K)+SO
73      SDOTY=S(K)*Y(K) + SDOTY
74      YMAG=Y(K)*Y(K) + YMAG
75      SMAG=S(K)*S(K) + SMAG
76      3 CONTINUE
77      C
78      C
79      C
80      SMAD=SUM/72.
81      DMEAN=SUM2/72.
82      SMSE=SUM1/72.
83      SMYM=YMAG*SMAG
84      IF(SMYM.LT.0.0001)GO TO 11
85      COF=SDOTY/SQRT(SMYM)
86      11 SO=SO/72.
87      WRITE(6,12)COF,SO
88      12 FORMAT(' ', 'COF=',F7.3,5X,'SO=',F7.3)
89      WRITE(6,4)SMAD,DMEAN,SMSE
90      4 FORMAT(' ', ' MEAN ABSOLUTE DIFFERENCE=',F7.3,3X,
91      1'MEAN DIFFERENCE=',F7.3,3X,'MEAN SQUARE ERROR '
92      2,'ESTIMATE=',F7.3)
93      RMSEE(I)=SMSE
94      YO=SO-DMEAN
95      SY=SQRT(YMAG/72.-YO*YO)
96      SS=SQRT(SMAG/72.-SO*SO)
97      RCOF=(SDOTY-72.*SO*YO)/(72.*SY*SS)
98      R(I)=RCOF
99      WRITE(6,13)YO,SY,SS,RCOF
100     13 FORMAT(' ', 'YO=',F7.3,5X,'SY=',F7.3,5X,'SS=',F7.3,
101     35X,'R=',F7.3)
102     2 CONTINUE
103     C      (CONTINUED ON NEXT PAGE)
104     C

```



```

: 105 C
: 106 C **** PRINT OUT FIRST 28 FORECAST VALUES
: 107 C   FOR R,MSEE,AVERAGE R, AND AVERAGE MSEE
: 108   WRITE(6,24)
: 109   SUM=0.00
: 110   SUM2=0.00
: 111   IO=0
: 112   WRITE(6,23)IO,R(1),RMSEE(1)
: 113   DO 22 I=2,29
: 114   IO=I-1
: 115   WRITE(6,23)IO,R(I),RMSEE(I)
: 116 23 FORMAT(' ',I5,F7.3,F7.1)
: 117   IF(ABS(R(I)-99.99).LT.1.00)GO TO 22
: 118   SUM=SUM+R(I)
: 119   SUM2=SUM2+RMSEE(I)
: 120 22 CONTINUE
: 121 24 FORMAT('1',3X,'I',5X,'R',5X,'MSEE')
: 122   SUM=SUM/TOTAL
: 123   SUM2=SUM2/TOTAL
: 124   WRITE(6,25)SUM,SUM2
: 125 25 FORMAT(' ', 'MEANS',F7.3,F7.1)
: 126 C
: 127 C
: 128 C **** PRINT OUT HOVMOLLER DIAGRAMS ***
: 129 C
: 130 C   ACTUAL DATA
: 131   IF((IPRINT*IPRINT).LT.9)GO TO 30
: 132   WRITE(6,28)
: 133 28 FORMAT('1','PART 1')
: 134   DO 26 I=1,28
: 135   WRITE(6,27)(HOV(I,J),J=1,36)
: 136 27 FORMAT(' ',36I3)
: 137 26 CONTINUE
: 138   WRITE(6,29)
: 139 29 FORMAT('1','PART 2')
: 140   DO 30 I=1,28
: 141   WRITE(6,27)(HOV(I,J),J=37,72)
: 142 30 CONTINUE
: 143 C ** FORECAST DATA
: 144   WRITE(6,28)
: 145   DO 31 I=1,28
: 146   WRITE(6,27)(FHOV(I,J),J=1,36)
: 147 31 CONTINUE
: 148   WRITE(6,29)
: 149   DO 32 I=1,28
: 150   WRITE(6,27)(FHOV(I,J),J=37,72)
: 151 32 CONTINUE
: 152   STOP
: 153   END

```

APPENDIX K

TEST DATA PROGRAM

```

C***** PROGRAM TO GENERATE TEST DATA ****
C
C      S=GENERATED HEIGHT REPORT
C      A=COSINE COMPONENT OF WAVE AMPLITUDE
C      B=SINE COMPONENT OF WAVE AMPLITUDE
C      F,C=AMPLITUDE/2 OF THE SPACE WAVE
C      Q,CQ=THE CORRESPONDING PHASE
C
C      DIMENSION RO(400),S(72),A(11),B(11),C(11),Q(11),
1F(11),CQ(11)
C      INTEGER T
C      DATA TOPI/6,28318/
C      P=TOPI/730.
C
C  ** TREND COEFFICIENTS INATIALIZED
C      ROM=51.0
C      G=-4.0
C      H=-11.0
C      Z=TOPI/360.
C      NUMB=90
C
C  ** THE LENGTH OF THE LONGEST WAVE
C      CUMB=FLOAT(NUMB)-60.
C
C  ** U IS USED TO DETERMINE THE ORIGIN
C      U=CUMB/2.+1.
C      WRITE(7,13)NUMB
C      WRITE(8,13)NUMB
C      WRITE(9,13)NUMB
13  FORMAT(I5)
C
C
C
C  ** GENERATE THE TREND
C      DO 1 T=1,NUMB
C      RO(T)=ROM+G*COS(P*T) + H*SIN(P*T)
C      X=(T-U)/CUMB
C
C
C
C  ** GENERATE SPACE WAVES
C      DO 2 M=1,11
C      V=FLOAT(M)
C
C  ** SET MEAN VALUES FOR A(M),B(M)
C      ROMB=1.5/V
C      ROMA=-0.8/V
C      SUM2=ROMB
C      SUM1=ROMA
C
C  ** ADD TIME WAVES TO SPACE WAVE AMPLITUDES
C      DO 3 I=1,11
C      W=FLOAT(I)
C
C  ** SET SPACE WAVES=0.00
C      C(I)=0.00
C      F(I)=0.00
C      Q(I)=0.00

```

```

      CQ(I)=0.00
C  ** PICK WHICH WAVES WILL BE NON-ZERO
      IF(I.EQ.M)GO TO 5
      IF(I.EQ.(2*M))GO TO 5
      IF(I.EQ.(3*M))GO TO 5
      GO TO 4
C  ** SET THE VALUE OF THE NON-ZERO COMPONENTS
      5 F(I)=0.9/W
      Q(I)=40.*W*Z
      CQ(I)=-10.*W*Z
      C(I)=0.7-0.03*V
      4 CONTINUE
      E=TOPI*X*W
C  ** CALCULATE THE SPACE WAVE COMPONENTS A(M),B(M)
      SUM2=SUM2+2.*F(I)*COS(E+Q(I))
      SUM1=SUM1+2.*C(I)*COS(E+CQ(I))
      3 CONTINUE
      A(M)=SUM1
      B(M)=SUM2
      2 CONTINUE
      WRITE(7,12)(A(J),J=1,11)
      WRITE(8,12)(B(J),J=1,11)
      12 FORMAT(11F7.2)
C
C
C  ** COMBINE TREND AND SPACE WAVES TO GET REPORT
      DO 7 L=1,72
      SUM3=RO(T)
      D=TOPI*FLOAT(L-37)/72.
      DO 6 M=1,11
      DM=D*FLOAT(M)
      SUM3=SUM3+2.*A(M)*COS(DM)+2.*B(M)*SIN(DM)
      6 CONTINUE
      S(L)=SUM3
      7 CONTINUE
C  ** STORE THE REPORT
      WRITE(10,15)(S(L),L=1,24),T,T
      WRITE(10,16)(S(L),L=25,48),T
      WRITE(10,17)(S(L),L=49,72),RO(T),X
      15 FORMAT(24F3.0,2I4)
      16 FORMAT(24F3.0,I4)
      17 FORMAT(24F3.0,2F4.1)
C
C
      1 CONTINUE
C  ** STORE THE TREND
      WRITE(9,14)(RO(T),T=1,NUMB)
      14 FORMAT(' ',11F7.3)
      STOP
      END

```

APPENDIX L

Table L.1: Results using other various techniques for smoothing. (Used on test sample)

Method:

1. Smoother Option No. 2 with variance adjustment.
2. Smoother Option No. 2 with no variance adjustment
3. Smoother Option No. 2 with no variance adjustment and the smooth mean square of the time-wave with wave number 1 calculated by $(0 + AA(1) + AA(2)) / 3$.
4. Same as method 2, except the frequency is not smoothed (i.e. not weighted)
5. Same as method 1, except the time-wave with wave number 1 is not smoothed.
6. Same as method 4 except the time-wave with wave number 1 is not smoothed.

The value "r" in this Appendix is the correlation coefficient (i.e. $r = R$).

Table L.1. Results Using Other Various Techniques for Smoothing

Forecast No.	Method 1 r	Method 1 MSEE	Method 2 r	Method 2 MSEE	Method 3 r	Method 3 MSEE	Method 4 r	Method 4 MSEE	Method 5 r	Method 5 MSEE	Method 6 r	Method 6 MSEE
0	0.674	35	0.655	37	0.622	40	0.516	47	0.515	49	0.506	47
1	0.517	48	0.478	60	0.451	64	0.453	48	0.363	66	0.410	53
2	0.565	49	0.558	73	0.535	77	-0.031	99	0.411	70	-0.057	104
3	0.833	30	0.830	34	0.819	35	-0.112	143	0.708	51	-0.151	152
4	0.183	40	0.170	43	0.117	46	0.174	44	0.005	58	0.109	51
5	0.708	27	0.695	38	0.685	40	0.132	48	0.599	44	0.096	53
6	0.632	21	0.656	24	0.650	25	0.370	24	0.549	36	0.345	27
7	0.585	30	0.563	39	0.572	40	0.558	16	0.561	44	0.559	17
8	0.788	15	0.786	16	0.793	16	0.678	16	0.686	31	0.695	15
9	0.651	26	0.624	33	0.627	33	0.693	18	0.582	42	0.710	17
10	0.908	10	0.899	18	0.895	18	0.633	21	0.799	27	0.655	20
11	0.594	25	0.569	31	0.569	31	0.435	29	0.479	38	0.471	28
12	0.756	15	0.746	24	0.750	24	0.320	42	0.630	26	0.324	42
13	0.880	12	0.882	18	0.879	17	0.250	80	0.808	20	0.257	78
14	0.856	8	0.858	12	0.859	11	0.396	69	0.725	17	0.409	65
15	0.763	17	0.758	20	0.752	20	0.231	94	0.598	32	0.233	93
16	0.195	34	0.121	51	0.097	52	-0.253	121	-0.023	54	-0.268	120
17	0.588	46	0.586	78	0.577	80	0.107	172	0.418	70	0.100	175
18	0.815	21	0.841	18	0.818	20	0.194	85	0.582	43	0.170	89
19	0.346	51	0.304	68	0.290	68	-0.052	86	0.163	67	-0.067	89
MEAN	0.642	28	0.629	37	0.619	38	0.285	65	0.508	44	0.275	67

APPENDIX M

Actual Forecasts Results (Southern Data Set)

Table M.1.

Results Using the Southern Data Set NUMB = 90
and JWAVE = 8.

Table M.2.

Results Using the Southern Data Set NUMB = 240

The value " r " in this Appendix is the correlation coefficient (i.e. $r = R$).

NOTE: Forecast numbers are listed to the left of these tables. Forecast number = 0 is for the last diagnostic report and is not considered in the Mean at the bottom of the table.

Table M.1. Results Using Southern Data Set

Part a

	Climatology		Persistence		Unsmooth NWAVE=1		Smoother No. 2 NWAVE=1		Unsmooth NWAVE=2		Smoother No. 2 NWAVE=2	
	r	MSEE	r	MSEE	r	MSEE	r	MSEE	r	MSEE	r	MSEE
0	0.907	72	1.000	0	0.866	72	0.798	102	0.933	39	0.593	163
1	0.820	87	0.953	23	0.796	88	0.685	124	0.872	58	0.434	198
2	0.830	79	0.949	25	0.784	88	0.707	113	0.882	52	0.455	184
3	0.814	71	0.916	41	0.778	79	0.703	101	0.856	54	0.443	166
4	0.789	71	0.874	59	0.755	79	0.700	93	0.828	57	0.469	148
5	0.772	73	0.830	78	0.726	86	0.679	96	0.770	74	0.452	147
6	0.748	80	0.805	90	0.674	99	0.659	101	0.707	91	0.479	139
7	0.756	77	0.770	103	0.599	115	0.672	97	0.586	120	0.532	126
8	0.752	77	0.737	118	0.597	114	0.683	93	0.586	117	0.558	117
9	0.787	64	0.758	110	0.597	106	0.717	79	0.569	112	0.583	104
10	0.828	54	0.746	116	0.637	95	0.746	71	0.536	115	0.596	98
11	0.815	49	0.731	120	0.646	82	0.689	72	0.526	102	0.518	102
12	0.870	37	0.772	113	0.703	67	0.842	40	0.600	80	0.719	60
13	0.848	39	0.735	124	0.704	64	0.856	36	0.614	76	0.754	53
14	0.834	48	0.748	117	0.691	77	0.843	44	0.589	93	0.756	63
15	0.820	53	0.780	104	0.663	86	0.812	53	0.544	106	0.736	72
16	0.815	51	0.796	96	0.681	80	0.776	58	0.562	102	0.710	78
17	0.809	53	0.812	94	0.682	80	0.768	61	0.539	106	0.711	82
18	0.826	46	0.826	88	0.689	75	0.786	54	0.470	116	0.737	75
19	0.776	69	0.776	105	0.635	101	0.750	74	0.379	157	0.712	95
20	0.777	76	0.770	106	0.617	114	0.737	85	0.324	186	0.707	104
21	0.758	82	0.772	105	0.593	122	0.712	92	0.294	198	0.696	111
22	0.747	74	0.772	103	0.567	114	0.683	90	0.273	187	0.662	116
23	0.799	58	0.836	82	0.622	93	0.719	77	0.358	155	0.710	102
24	0.839	48	0.854	82	0.629	84	0.750	70	0.382	140	0.735	100
25	0.819	57	0.837	96	0.603	86	0.765	72	0.323	144	0.746	107

Table M.1. Part a, cont'

26	0.817	63	0.806	104	0.612	91	0.797	70	0.330	150	0.762	108
27	0.750	80	0.763	121	0.533	104	0.757	84	0.267	158	0.702	132
28	0.736	86	0.749	131	0.523	104	0.777	85	0.282	151	0.714	136
MEAN	0.798	64	0.803	95	0.655	92	0.742	78	0.530	116	0.635	112

Table M.1. Part b cont'

27	0.207	186	0.647	152	0.545	171	0.183	187	0.623	176	0.236	191
28	0.237	177	0.675	156	0.554	181	0.212	171	0.644	183	0.270	180
MEAN	0.511	125	0.640	108	0.577	120	0.494	132	0.638	111	0.493	137

Table M.1. Results Using Southern Data Set

NUMB = 90
JWAVE = 8

Part c

	Unsmooth NWAVE=6		Smoother No. 1 NWAVE=6		Smoother No. 2 NWAVE=6		Smoother No. 3 NWAVE=6		Smoother No. 2 NWAVE=11		Unsmooth NWAVE=11	
	r	MSEE	r	MSEE	r	MSEE	r	MSEE	r	MSEE	r	MSEE
0	0.958	29	0.541	178	0.611	180	0.559	175	0.541	178	0.952	31
1	0.876	57	0.445	191	0.537	165	0.467	189	0.488	180	0.829	74
2	0.841	66	0.474	177	0.592	144	0.514	168	0.576	149	0.768	91
3	0.763	83	0.473	158	0.618	122	0.530	146	0.620	121	0.703	101
4	0.680	102	0.470	149	0.605	118	0.517	140	0.611	117	0.663	106
5	0.613	120	0.438	153	0.554	131	0.471	149	0.559	130	0.642	112
6	0.515	145	0.386	164	0.509	144	0.404	164	0.592	149	0.569	135
7	0.424	166	0.398	159	0.514	141	0.373	170	0.482	151	0.513	149
8	0.516	138	0.330	171	0.504	141	0.339	175	0.447	157	0.584	125
9	0.549	122	0.310	166	0.514	129	0.318	169	0.454	146	0.587	114
10	0.593	111	0.335	156	0.497	126	0.319	161	0.455	140	0.582	111
11	0.573	108	0.294	150	0.388	133	0.239	159	0.361	144	0.512	120
12	0.659	88	0.518	98	0.601	77	0.478	96	0.556	94	0.617	92
13	0.680	81	0.594	84	0.662	62	0.573	75	0.641	74	0.657	85
14	0.635	96	0.726	71	0.699	65	0.673	71	0.704	74	0.635	98
15	0.576	109	0.776	63	0.675	74	0.682	75	0.706	78	0.603	105
16	0.552	109	0.792	51	0.641	81	0.701	71	0.690	79	0.587	103
17	0.496	119	0.852	41	0.677	75	0.740	62	0.733	69	0.515	118
18	0.368	145	0.863	38	0.716	67	0.746	58	0.763	57	0.349	155
19	0.231	205	0.822	60	0.712	85	0.712	79	0.724	77	0.204	217
20	0.194	238	0.762	92	0.678	105	0.669	102	0.683	96	0.171	247
21	0.204	242	0.693	129	0.638	123	0.620	124	0.636	119	0.190	245
22	0.207	220	0.581	161	0.563	145	0.522	154	0.571	144	0.230	213
23	0.309	181	0.558	169	0.617	139	0.568	147	0.610	143	0.355	169
24	0.339	168	0.556	164	0.629	151	0.562	158	0.625	151	0.374	158

Table M.1. Part c cont.

25	0.256	184	0.623	143	0.649	168	0.602	160	0.661	155	0.275	180
26	0.291	186	0.602	151	0.640	184	0.575	176	0.644	168	0.273	193
27	0.235	200	0.535	179	0.581	212	0.527	199	0.588	196	0.192	215
28	0.302	182	0.526	200	0.601	211	0.531	204	0.593	206	0.250	199
MEAN	0.482	142	0.561	132	0.601	126	0.535	136	0.595	127	0.480	144

Table M.2. Results Using Southern Data Set

NUMB = 240
JWAVE = 8

Part a

	Climatology		Persistence		Unsmooth NWAVE=1		Smoother No. 1 NWAVE=1		Smoother No. 2 NWAVE=1		Smoother No. 3 NWAVE=1	
	r	MSEE	r	MSEE	r	MSEE	r	MSEE	r	MSEE	r	MSEE
0	0.565	72	1.000	0	0.696	49	0.678	53	0.552	74	0.654	59
1	0.599	74	0.943	12	0.714	53	0.685	62	0.576	78	0.672	64
2	0.697	70	0.830	40	0.772	59	0.725	71	0.671	77	0.749	65
3	0.725	58	0.662	69	0.765	52	0.678	70	0.717	62	0.747	58
4	0.710	55	0.568	81	0.738	49	0.651	67	0.692	60	0.732	54
5	0.678	51	0.400	101	0.703	43	0.597	62	0.662	54	0.707	48
6	0.656	50	0.412	93	0.652	42	0.605	55	0.632	52	0.725	41
7	0.592	58	0.303	108	0.571	48	0.567	59	0.568	59	0.699	43
8	0.557	68	0.335	113	0.539	59	0.594	62	0.532	70	0.700	46
9	0.499	75	0.201	134	0.468	64	0.555	64	0.491	72	0.658	49
10	0.529	73	0.229	136	0.484	65	0.633	55	0.546	66	0.712	43
11	0.527	71	0.194	141	0.464	64	0.647	51	0.564	61	0.720	40
12	0.591	61	0.337	119	0.551	55	0.719	40	0.641	49	0.786	30
13	0.629	50	0.355	107	0.590	43	0.719	37	0.676	40	0.780	27
14	0.639	50	0.504	88	0.612	43	0.701	41	0.686	40	0.780	28
15	0.635	48	0.561	76	0.590	43	0.654	46	0.672	40	0.735	32
16	0.548	62	0.594	72	0.510	55	0.596	55	0.605	50	0.662	43
17	0.548	67	0.422	100	0.501	62	0.612	59	0.594	57	0.647	50
18	0.504	75	0.252	132	0.507	65	0.621	59	0.573	61	0.634	53
19	0.532	73	0.034	167	0.589	58	0.617	62	0.572	64	0.621	58
20	0.497	80	-0.030	187	0.594	59	0.603	64	0.549	69	0.601	61
21	0.482	78	-0.083	189	0.601	56	0.558	68	0.535	66	0.572	62
22	0.436	83	-0.018	181	0.552	63	0.482	78	0.507	69	0.519	68
23	0.443	79	-0.045	183	0.513	68	0.414	85	0.498	69	0.473	72
24	0.445	86	0.007	188	0.478	80	0.379	99	0.518	73	0.452	83

Table M.2. Part a, cont'

25	0.467	80	0.032	179	0.467	80	0.381	96	0.520	70	0.459	79
26	0.525	74	0.265	139	0.539	72	0.463	87	0.611	59	0.545	70
27	0.493	75	0.313	126	0.500	75	0.418	90	0.582	61	0.519	70
28	0.518	76	0.436	113	0.569	70	0.436	94	0.622	60	0.555	70
MEAN	C.561	68	0.322	121	0.576	59	0.582	66	0.593	61	0.649	54

Table M.2. Results Using Southern Data Set

NUMB = 240
JWAVE = 8

Part b

	Unsmooth NWAVE=2		Smoother No. 2 NWAVE=2		Smoother No. 3 NWAVE=2		Unsmooth NWAVE=3		Smoother No. 3 NWAVE=3		Smoother No. 1 NWAVE=4	
	r	MSEE	r	MSEE	r	MSEE	r	MSEE	r	MSEE	r	MSEE
0	0.743	45	0.544	77	0.563	68	0.713	53	0.643	65	0.612	74
1	0.750	50	0.533	86	0.591	73	0.683	64	0.662	60	0.607	84
2	0.815	48	0.601	89	0.672	76	0.733	67	0.725	66	0.658	86
3	0.827	39	0.602	80	0.672	67	0.711	64	0.681	64	0.621	89
4	0.820	36	0.577	77	0.630	67	0.696	61	0.617	66	0.577	94
5	0.798	31	0.540	71	0.631	54	0.673	56	0.572	59	0.482	101
6	0.737	34	0.511	70	0.647	47	0.624	58	0.560	54	0.450	98
7	0.619	46	0.459	73	0.641	47	0.518	69	0.544	55	0.408	99
8	0.557	59	0.401	88	0.660	50	0.504	75	0.576	58	0.448	96
9	0.486	65	0.380	86	0.626	53	0.445	79	0.573	56	0.458	88
10	0.486	67	0.455	78	0.692	46	0.455	78	0.654	48	0.482	67
11	0.477	65	0.474	72	0.688	45	0.433	77	0.644	48	0.616	58
12	0.510	62	0.549	61	0.764	35	0.458	72	0.702	41	0.724	41
13	0.534	51	0.590	48	0.759	33	0.442	66	0.687	38	0.688	42
14	0.534	55	0.614	47	0.773	32	0.450	68	0.672	42	0.666	45
15	0.508	56	0.630	42	0.707	41	0.422	68	0.606	49	0.579	53
16	0.447	68	0.539	55	0.646	52	0.420	73	0.555	59	0.561	58
17	0.485	70	0.507	64	0.581	65	0.433	78	0.512	71	0.535	68
18	0.523	69	0.485	69	0.563	70	0.482	75	0.531	70	0.576	64
19	0.609	60	0.521	67	0.557	73	0.559	67	0.567	67	0.581	67
20	0.600	65	0.500	72	0.570	72	0.592	65	0.598	63	0.590	68
21	0.621	62	0.517	67	0.544	72	0.626	57	0.579	63	0.576	71
22	0.580	69	0.507	67	0.597	78	0.646	56	0.518	71	0.524	81
23	0.554	74	0.490	69	0.424	87	0.618	62	0.432	81	0.447	97

Table M.2. Part b cont.

24	0.520	85	0.490	77	0.397	99	0.571	77	0.396	94	0.421	111
25	0.522	84	0.491	75	0.364	100	0.527	85	0.350	98	0.386	118
26	0.582	77	0.572	66	0.443	90	0.573	81	0.401	93	0.426	114
27	0.572	77	0.569	64	0.398	93	0.525	89	0.327	99	0.370	119
28	0.609	75	0.619	61	0.434	93	0.553	88	0.358	101	0.394	118
MEAN	0.595	61	0.526	69	0.592	65	0.549	70	0.557	65	0.534	82

Table M.2. Results Using Southern Data Set

NUMB = 240 Part c

	Smoother No. 2 NWAVE=4 JWAVE=8			Smoother No. 3 NWAVE=5 JWAVE=8			Smoother No. 3 NWAVE=2 JWAVE=5			Smoother No. 3 NWAVE=2 JWAVE=11			Smoother No. 3
	r	MSEE		r	MSEE		r	MSEE		r	MSEE		
0	0.591	72		0.695	51		0.542	71		0.571	67		
1	0.564	82		0.709	54		0.566	76		0.581	75		
2	0.626	83		0.747	59		0.647	80		0.665	77		
3	0.624	74		0.701	59		0.642	71		0.671	67		
4	0.605	71		0.625	66		0.615	68		0.632	66		
5	0.579	66		0.575	62		0.599	58		0.628	55		
6	0.540	68		0.555	60		0.617	50		0.651	47		
7	0.468	76		0.529	63		0.597	51		0.640	47		
8	0.433	88		0.551	66		0.613	56		0.657	50		
9	0.391	90		0.550	65		0.579	58		0.627	52		
10	0.476	80		0.641	54		0.643	52		0.694	46		
11	0.478	77		0.655	50		0.647	51		0.686	46		
12	0.577	62		0.730	39		0.738	38		0.765	35		
13	0.572	57		0.696	40		0.744	34		0.762	33		
14	0.608	54		0.685	42		0.774	32		0.773	32		
15	0.605	53		0.619	49		0.712	40		0.702	42		
16	0.563	61		0.556	61		0.651	50		0.636	53		
17	0.503	74		0.494	76		0.580	65		0.585	64		
18	0.503	76		0.492	78		0.569	69		0.567	70		
19	0.504	79		0.519	77		0.572	70		0.556	73		
20	0.482	82		0.547	75		0.586	68		0.565	73		
21	0.490	77		0.546	71		0.570	67		0.537	73		
22	0.451	80		0.497	77		0.547	69		0.501	77		
23	0.446	79		0.469	81		0.482	78		0.426	87		

Table M.2. Part c cont'

24	0.439	87	0.460	90	0.504	87	0.457	87	0.389	100
25	0.409	90	0.438	91	0.470	93	0.441	87	0.369	99
26	0.444	88	0.474	87	0.488	94	0.526	75	0.449	89
27	0.409	90	0.403	95	0.414	103	0.484	79	0.405	91
28	0.445	91	0.410	100	0.429	108	0.494	82	0.427	94
MEAN	0.508	76	0.567	67	0.573	69	0.596	63	0.591	65

APPENDIX N

Actual Forecast Results (Northern Data Set)

Table N.1.

Results Using Northern Data Set NUMB = 240.

The value "r" in this Appendix is the correlation coefficient (i.e. $r = R$).

NOTE: Forecast numbers are listed to the left of these tables. Forecast number = 0 is for the last diagnostic report and is not considered in the Mean at the bottom of the table.

Table N.1. Results Using Northern Data Set NUMB=240
(Part a) JWAVE= 8

	Persistence		Climatology		Unsmooth NWAWE=2		Unsmooth NWAWE=3	
	r	MSEE	r	MSEE	r	MSEE	r	MSEE
0	1.000	0	0.835	28	0.464	54	0.439	48
1	0.874	14	0.723	37	0.205	74	0.283	62
2*								
3	0.476	64	0.485	64	0.191	83	0.295	71
4	0.352	84	0.395	82	0.296	84	0.303	80
5	0.330	89	0.392	86	0.422	76	0.336	82
6	0.339	93	0.415	92	0.583	69	0.415	84
7	0.349	89	0.439	89	0.644	64	0.451	82
8	0.238	113	0.401	108	0.654	77	0.498	95
9	0.203	114	0.421	109	0.600	87	0.509	103
10	0.149	126	0.412	120	0.623	98	0.531	119
11	0.160	120	0.397	126	0.529	117	0.416	152
12	0.232	112	0.409	125	0.542	119	0.417	164
13	0.168	146	0.318	164	0.469	159	0.359	210
14	0.116	197	0.320	203	0.455	198	0.384	252
15	0.147	180	0.385	180	0.458	189	0.386	246
16	0.137	178	0.432	165	0.407	172	0.460	227
17	0.160	173	0.463	156	0.493	175	0.435	231
18	0.213	156	0.521	134	0.545	153	0.491	204
19	0.227	126	0.500	111	0.460	154	0.410	203
20	0.190	121	0.433	103	0.395	154	0.350	200
21	0.194	117	0.377	110	0.291	183	0.237	232
22	0.279	125	0.451	121	0.397	183	0.357	225
23	0.366	113	0.542	110	0.490	171	0.442	208
24	0.410	106	0.582	98	0.551	147	0.498	183
25	0.367	118	0.537	121	0.559	169	0.488	207
26	0.394	113	0.510	126	0.556	176	0.487	210
27	0.499	89	0.520	116	0.565	171	0.486	208
28	0.507	99	0.487	140	0.526	102	0.460	234
MEAN	0.323	127	0.491	128	0.464	132	0.447	183

* The actual data for forecast No. 2 were missing and would appear in the printout as:

r.	MSEE
99.99	-10.0

Table N.1. Results Using Northern Data Set NUMB=240
 (Part b) JWAVE= 8
 Smoothing Option=No. 3

	NWAVE = 1		NWAVE = 3		NWAVE = 5		NWAVE = 7	
	r	MSEE	r	MSEE	r	MSEE	r	MSEE
0	0.788	21	0.651	42	0.650	40	0.557	49
1	0.674	32	0.576	53	0.526	54	0.315	83
2*								
3	0.602	43	0.582	56	0.491	63	0.183	118
4	0.648	43	0.680	46	0.628	51	0.348	103
5	0.712	38	0.756	37	0.668	47	0.408	96
6	0.748	38	0.806	33	0.734	43	0.519	81
7	0.759	36	0.811	32	0.738	41	0.535	75
8	0.719	49	0.743	49	0.733	51	0.562	75
9	0.724	49	0.683	57	0.633	64	0.507	80
10	0.633	68	0.549	78	0.587	75	0.527	81
11	0.614	73	0.587	73	0.619	73	0.590	75
12	0.627	72	0.632	66	0.726	63	0.752	64
13	0.546	104	0.575	91	0.692	89	0.650	98
14	0.472	149	0.423	145	0.569	139	0.356	165
15	0.478	138	0.406	135	0.493	136	0.159	177
16	0.462	136	0.313	141	0.427	139	0.056	191
17	0.458	135	0.333	137	0.407	140	0.049	199
18	0.435	130	0.257	137	0.351	138	0.021	200
19	0.321	120	0.243	110	0.315	117	0.077	168
20	0.113	133	0.105	112	0.250	113	0.128	150
21	0.019	147	0.099	110	0.175	123	0.132	151
22	0.062	161	0.094	138	0.109	158	0.032	191
23	0.142	152	0.156	136	0.116	163	0.026	195
24	0.174	145	0.205	134	0.147	158	0.098	177
25	0.145	159	0.215	152	0.188	170	0.204	176
26	0.151	161	0.253	156	0.198	174	0.296	166
27	0.278	134	0.391	138	0.323	150	0.451	138
28	0.402	140	0.521	152	0.369	170	0.557	150
MEAN	0.483	111	0.480	108	0.488	116	0.342	145

* See Part a of this table.